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COMPUTER-AIDED SPACE SHUTTLE ORBITER WING DESIGN STUDY

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16. Abstract

An analytical and experimental investigation has been made to provide a space shuttle orbiter wing design that met the guideline requirements of landing performance, stability, and hypersonic trim for a specified center-of-gravity envelope. The analytical study was facilitated by the use of the Optimal Design Integration system (ODIN) and the experimental part of the investigation was conducted in the Langley low-turbulence pressure tunnel and the Langley continuous-flow hypersonic tunnel.

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COMPUTER-AIDED SPACE SHUTTLE ORBITER WING DESIGN STUDY

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SUMMARY

An analytical and experimental investigation has been made to define a space shuttle orbiter wing configuration meeting the requirements for landing performance, stability, and hypersonic trim for a specified center-of-gravity envelope. The analytical part of the study was facilitated by the use of the Optimal Design Integration system (ODIN). Limited experimental studies were made in the Langley low-turbulence pressure tunnel and the Langley continuous-flow hypersonic tunnel to verify the aerodynamic characteristics of the orbiter configuration selected analytically.

Use of the ODIN system greatly simplified the handling of analytical data while maintaining compliance with the space shuttle general vehicle requirements and allowed the expedient selection of a desirable wing planform. The analytical aerodynamic estimates obtained by using the ODIN system were in reasonable agreement with experimental results obtained subsequently for the orbiter configuration selected. The analytical study suggested reductions in wing sweep to produce a minimum-wing-area (minimum-weight) configuration. Reductions in wing area and sweep also enhanced the high-angle-of-attack trim capability at hypersonic speeds. This trend, however, was constrained by entry heating considerations to preclude wing-leading-edge sweep angles below 45°. Hypersonic considerations of elevon size effects redirected the study toward unsweeping the wing trailing edge to provide increased trimmed angle-of-attack capability for a 46.8° swept-wing configuration which satisfied the guideline subsonic flight requirements. The analytically selected orbiter configuration required minor experimental wind-tunnel refinements to provide a viable orbiter configuration. The primary refinement

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was the addition of a small planform fillet to increase lift coefficients at landing attitudes. Significant reductions in lift-drag ratio losses due to the addition of attitude control propulsion system wing-tip pods were attained by tailoring the external shape of pods designed to house the roll-attitude control system. The use of sequentially deflected segmented elevons improved subsonic trimmed lift-drag ratios which may be beneficial to landing-approach glide-slope performance.

INTRODUCTION

As the space shuttle program has matured, significant effort has been devoted to reductions in system weight resulting, in turn, in a smaller orbiter vehicle. The payload weight and volume requirements remained fixed, however, and the variations in potential payload centers of gravity exert an increased influence on the flight characteristics of the smaller vehicle. In addition to wide center-of-gravity excursions due to the various payloads, other interacting requirements such as a maximum allowable landing speed, acceptable unaugmented low-speed flying qualities, and stable hypersonic trim at high angles of attack present a formidable challenge to aerospace design.

Definition of a near-optimum design solution to these conflicting requirements within a reasonable time frame requires the rapid examination of a large number of configuration variables. Studies of means to automate design problems such as these have resulted in the formulation of an Optimal Design Integration system (ODIN) described in reference 1. The derived system is a unique approach to design synthesis in that it allows interactive operation of existing analysis programs representing the various problem-related technology areas. This paper presents the results of an initial utilization of this approach.

In the present study an existing orbiter design with known weight characteristics but unacceptable aerodynamic performance served as a baseline and the body, tail, and internal arrangement were held constant. The ODIN system was utilized to determine rapidly a wing configuration meeting the system requirements insofar as possible at a minimum weight. The aerodynamic characteristics of the analytically derived configuration were verified by experimental studies at subsonic and hypersonic speeds.

Also included in the subsonic experimental studies were the effects of a wing leading-edge planform fillet, wing twist, and the use of segmented elevons. The effects of wing-tip-mounted attitude-control propulsion system pods were also determined at subsonic speeds.

SYMBOLS

Values are given in both SI and U.S. Customary Units. The measurements and calculations were made in U.S. Customary Units.

A	aspect ratio
$\bar{c}$	mean aerodynamic chord, meters (ft)
C_D	drag coefficient, $\frac{\text{Drag}}{q_\infty S_{ref}}$
C_L	lift coefficient, $\frac{\text{Lift}}{q_\infty S_{ref}}$
C_m	pitching-moment coefficient, $\frac{\text{Pitching moment}}{q_\infty S_{ref} \bar{c}}$
$C_{m_{C_L}}$	static longitudinal stability level based on $\bar{c}$, $\frac{\partial C_m}{\partial C_L}$
C_N	normal-force coefficient, $\frac{\text{Normal force}}{q_\infty S_{ref}}$
i_{wing}	incidence angle of wing, deg
L/D	lift-drag ratio
l	length of fuselage, meters (ft)
M	Mach number
q_∞	free-stream dynamic pressure, newtons per meter^2 (lb/ft^2)
R_l	free-stream Reynolds number based on l
S_{elevon}	elevon area, meters^2 (ft^2)
S_{ref}	wing reference area, meters^2 (ft^2)

$V_{min,des}$ minimum flying speed at design conditions and $\alpha = 17^{o}$, knots

x,y coordinates of exposed reference wing planform (origin at exposed root chord leading edge)

x_{cg} center-of-gravity location from nose of vehicle

x_{wing} location of exposed wing leading-edge root chord from nose of vehicle, meters (ft)

XSF scale factor for x-ordinates of exposed wing planform

YSF scale factor for y-ordinates of exposed wing planform

α angle of attack, deg

δ_e elevon deflection angle, deg

λ taper ratio

Λ_{le} leading-edge sweep angle, deg

Λ_{te} trailing-edge sweep angle, deg

Subscripts:

e_1,e_2,e_3 inboard to outboard elevon segments

des design conditions

max maximum

min	minimum
trim	trim conditions

Abbreviations:

ACPS	attitude control propulsion system
BW_PV_2	body-plane (untwisted) wing-large vertical tail (subsonic model)
BW_TV_2F	body-twisted wing-large vertical tail-fillet (subsonic model)
BW_PV_1	body-plane (untwisted) wing-small vertical tail (hypersonic model)
Design P/L	design payload condition (18 144 kg (40 000 lb) at payload bay centroid)
JSC	NASA Johnson Space Center
Mod	modified
ODIN	Optimal Design Integration system
P_1	semifaired ACPS tip pod design
P_2	fully tailored ACPS tip pod design
P/L out	payload-out condition
TPS	thermal protection system
W_1 to W_{35}	wing designations
W/40K PL	with 18 144 kg (40 000 lb) payload at payload bay centroid

METHOD OF ANALYSIS

An existing orbiter design, designated the 040A (ref. 2), of known weight characteristics with aerodynamic performance characteristics unacceptable relative to established criteria, was used as a baseline configuration. The body, vertical tail, and internal arrangement were held constant and the ODIN system was utilized to determine a wing geometry and location to meet the system requirements in the longitudinal mode. Use of the ODIN system allowed rapid perturbation of the orbiter wing geometry by directing the sequential execution and data retrieval from a selected group of analytical programs. The specific programs were chosen to provide pertinent information representing the technology areas of subsonic and hypersonic aerodynamics, stability and control, weight, balance, geometry, and graphics.

Analysis Criteria

The guidelines established for the wing design study (see table I) were in accord with those outlined and/or implied by the general vehicle requirements of the space shuttle program. The orbiter geometry and accompanying weight statement used as a study baseline are indicated in table II and table III, respectively. The design criteria are further depicted on the design envelope of payload loadings for the orbiter shown in figure 1. The requirement of a minimum design speed of 150 knots or less is shown for an 18 144 kg (40 000 lb) payload located at the half-length station of the payload bay. This payload loading represents the maximum return payload anticipated in its most forward location in the payload bay. Minimum design speed ($V_{min,des}$) is used herein to denote the level flying speed at $\alpha = 17^{\circ}$ and sea-level standard day conditions for an orbiter having the design payload loading. Additional design criteria included stable subsonic static margin and high-angle-of-attack trim capability ($\alpha_{max} = 50^{\circ}$) hypersonically over the center-of-gravity range dictated by the payload envelope.

Parameters descriptive of these criteria, along with descriptive weights and geometry data, were output in the ODIN summary reports for each wing design and are included herein as an appendix. Pertinent information for the wings is summarized in the appendix. These summary reports enabled the user to determine the wing having the most desirable characteristics.

TABLE I.- ANALYSIS CRITERIA

Baseline orbiter configuration:

JSC-040A geometry (ref. 2)

040A weights (table II)

Orbiter design criteria:

Subsonic:

(a) C_m/C_L (All payloads) $\leqq 0$

(b) $V_{min,des}$ (Design payload) $\leqq$ 150 knots at $\alpha = 17^o$

Hypersonic:

(a) $\alpha_{max,trim}$ (Design payload) = 50^o

(b) $\Lambda_{le} \geqq 45^o$

TABLE II.- BASELINE GEOMETRY

[XSF = YSF = 1.0]

Overall configuration:		
Area, planform, m^2 (ft^2)	346.0	(3723.0)
Length, nose to wing leading edge at body, m (in.)	15.765	(620.68)
Length, nose to wing $\bar{c}/4$, m (in.)	22.453	(883.97)
Angle, ground plane, deg		17.00
Fuselage:		
Area, wetted, m^2 (ft^2)	586.2	(6307.0)
Length, nose to end of body, m (in.)	33.401	(1315.0)
Wing:		
Area, reference, m^2 (ft^2)	293.3	(3155.8)
Area, elevon, m^2 (ft^2)	42.33	(455.52)
Span, m (in.)	22.403	(882.00)
Chord, mean aerodynamic, m (in.)	15.485	(609.63)
Chord, center-line root, m (in.)	22.787	(897.14)
Chord, tip, m (in.)	3.386	(133.32)
Taper ratio, theoretical		0.14860
Aspect ratio, theoretical		1.7118
Aspect ratio, exposed span		1.5882
Angle, leading-edge sweep, deg		59.998
Angle, trailing-edge sweep, deg		0.0
Angle, dihedral, deg		7.0
Angle, incidence, deg		1.5
Airfoil section, root	NACA 0008-64	
Airfoil section, tip	NACA 0008-64	
x_{wing}, m (in.)	18.289	(720.04)

TABLE III.- BASELINE WEIGHT STATEMENT

Wing group, kg (lb)	6699.7 (14 704)
Tail group, kg (lb)	1496.9 (3300)
Body group, kg (lb)	16 391.1 (36 136)
Induced environmental protection, kg (lb)	12 265.7 (27 041)
Landing, docking, recovery, kg (lb)	4301.0 (9482)
Propulsion – ascent, kg (lb)	10 065.3 (22 190)
Propulsion – cruise, kg (lb)	98.4 (217)
Propulsion – auxiliary, kg (lb)	4140.9 (9129)
Prime power, kg (lb)	1583.0 (3490)
Electrical conversion and distribution, kg (lb)	1285.9 (2835)
Hydraulic conversion and distribution, kg (lb)	440.0 (970)
Surface controls, kg (lb)	1183.9 (2610)
Avionics, kg (lb)	2501.6 (5515)
Environmental control, kg (lb)	1397.1 (3080)
Personnel provisions, kg (lb)	384.2 (847)
Growth/uncertainty, kg (lb)	5305.2 (11 696)
Dry weight, kg (lb)	69 509.9 (153 242)
Personnel, kg (lb)	714.4 (1575)
Payload, kg (lb)	18 143.8 (40 000)
Residual and reserve fluids, kg (lb)	1376.2 (3034)
Landing weight, kg (lb)	89 744.3 (197 851)
ACPS propellant (entry), kg (lb)	3724.9 (8212)
Entry weight, kg (lb)	93 469.2 (206 063)

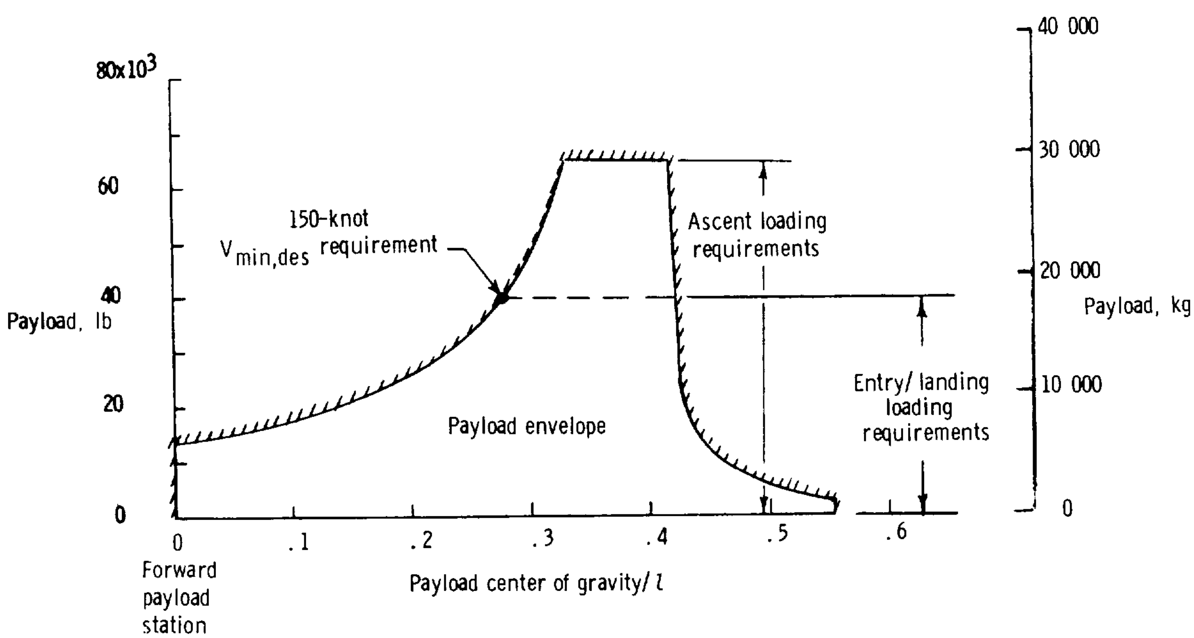
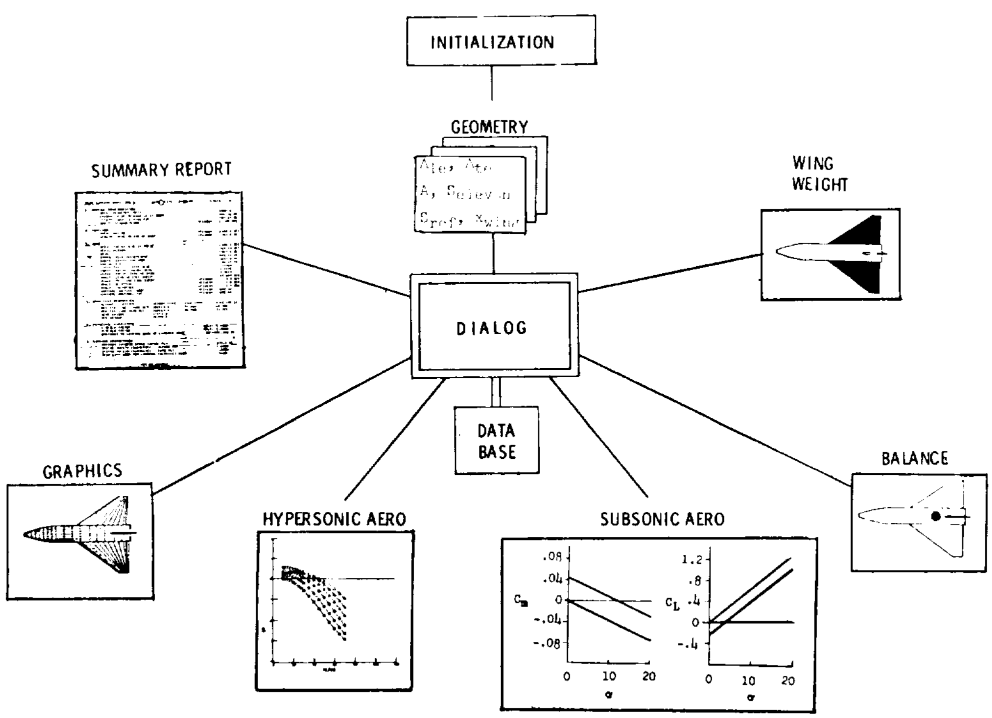


Figure 1.- Payload envelope depicting loading and flight requirements for the space shuttle orbiter.

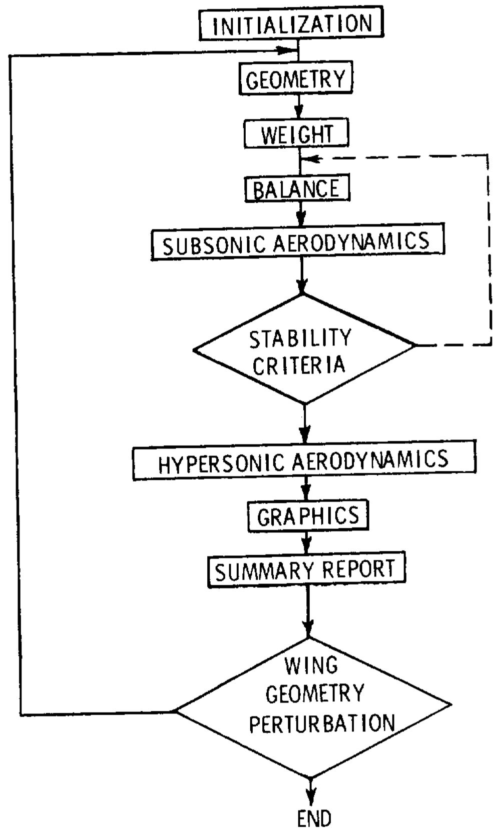
Method

The general programing arrangement within the ODIN system is shown in figure 2(a), and the detailed programing arrangement for this problem is shown in figure 2(b). After initialization, the geometry program calculated the geometric characteristics of a matrix of wings selected as reasonable perturbations from the baseline shape. This information was stored in the data base by the executive program DIALOG. The calculations then proceeded sequentially for each wing geometry. The necessary information needed to calculate wing weight was retrieved from the data base by utilizing the DIALOG program which also input these values into the weight programs. Weights were assigned to the fuselage structure, to the fuselage-contained components, and to the vertical tail and were held constant during the study. The structural and the thermal protection system weights of the wing were calculated by the methods described in reference 3. This process was repeated through the balance program which calculated the centers of gravity of the vehicle for the payload-in and payload-out conditions. The



(a) General programing arrangement.

Figure 2.- Orbiter wing design problem formulation within the ODIN system.



(b) Programing arrangement.

Figure 2.- Concluded.

static margins and trimmed C_L were obtained from the subsonic aerodynamics program (ref. 4). Static margins were obtained for payload-out and the design-payload conditions. The payload-out static margin was weighed against a target static margin of $0.03\bar{c} \pm 0.002$, which assured longitudinal stability at the guideline subsonic flight conditions. If this condition was not met, the system adjusted the longitudinal position of the wing and performed an iterative looping back through the geometry, balance, and subsonic aerodynamics programs until convergence was attained. After the final subsonic static margin calculation, the hypersonic characteristics were calculated by using the methods outlined in reference 5. The graphics program was then used to depict the vehicle and plot the aerodynamic characteristics. A summary report provided the pertinent information such as wing geometry, the weight of the vehicle, the center-of-gravity locations, the minimum design speed, and the maximum hypersonic trim angle of attack and thereby completed the design calculations for a specific wing.

Study Variables

The wing study variables were leading-edge sweep angle, aspect ratio, and exposed wing area. These parameters were varied by using x- and y-scale factors (XSF and YSF) to depict the exposed planform of a study wing which is represented by the dashed outline in figure 3 (that is, a wing planform having $XSF = 0.9$ and $YSF = 1.3$ has exposed root and tip chords equal to 0.9 times the exposed root and tip chords of the baseline wing and an exposed span equal to 1.3 times the baseline exposed wing span). The trailing-edge sweep angle was fixed ($\Lambda_{te} = 0^{\circ}$) and the taper ratio of the exposed wing was held constant for most of the study. To meet the subsonic static margin requirement, the longitudinal wing position x_{wing} was varied. For some of the wings considered in this study, Λ_{te} and S_{elevon} were also varied. Twenty-five different wing planforms were considered in the initial matrix which covered a broad spectrum of possible wing designs. (See fig. 4(a).)

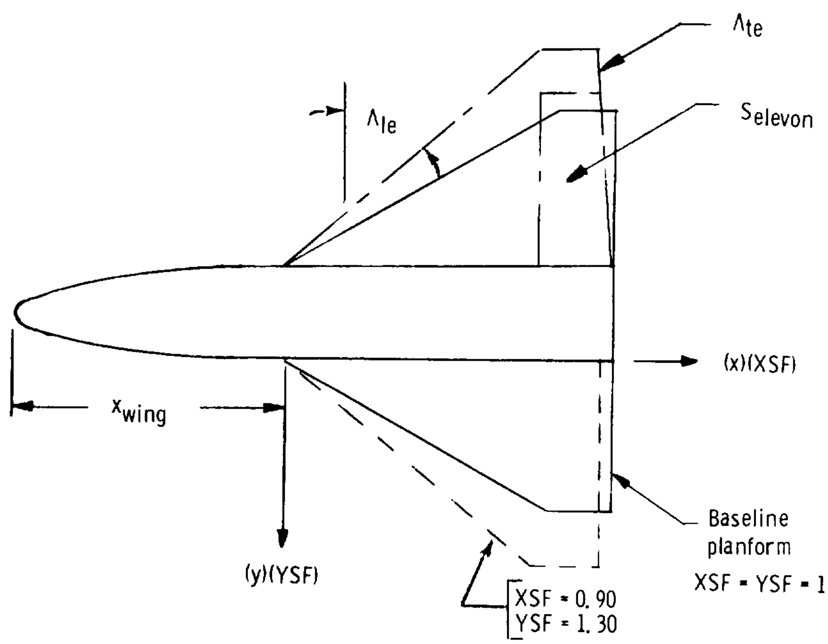
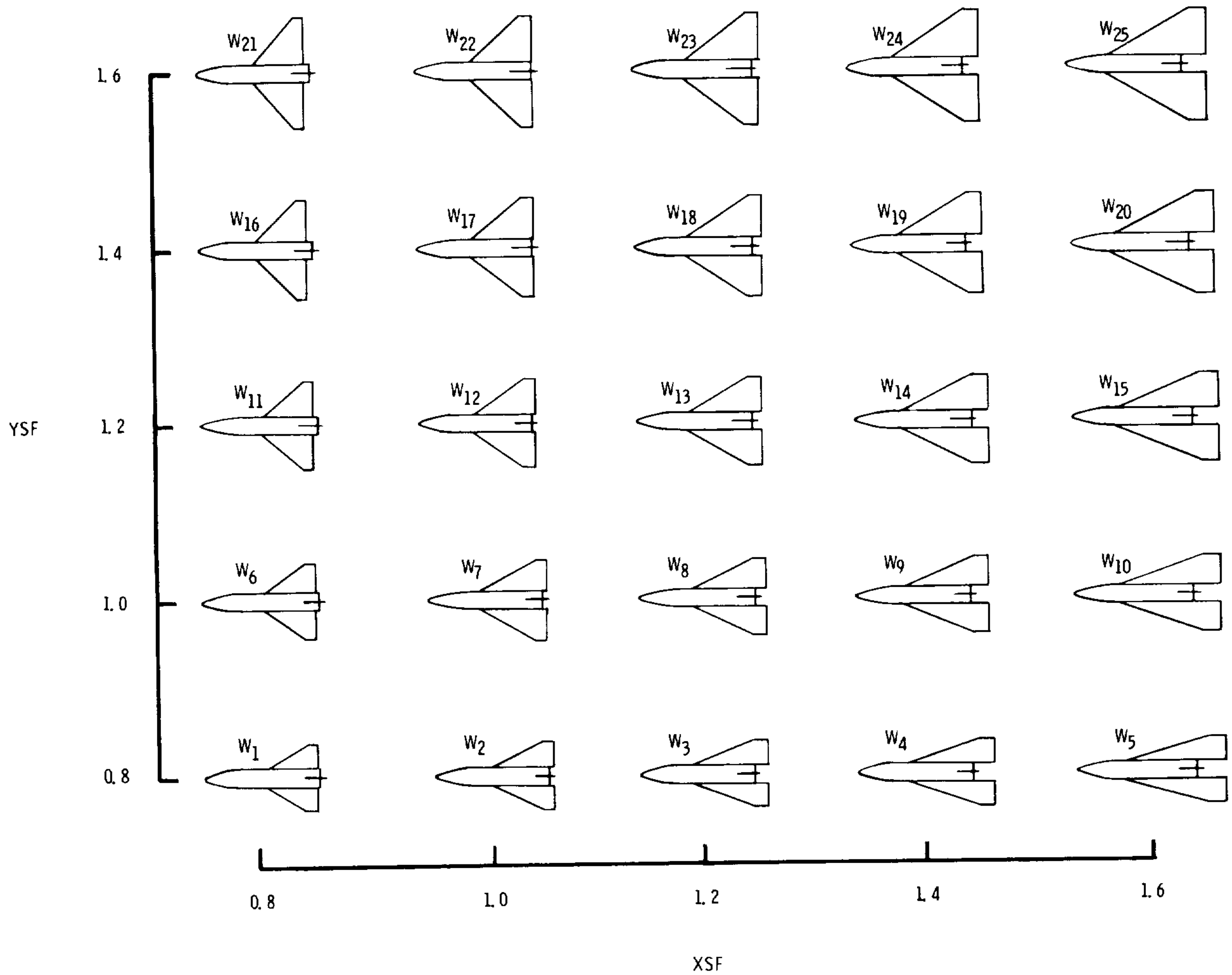


Figure 3.- Study variables.

The results of this matrix calculation were displayed in computer-generated maps of combined design and performance data (figs. 4(b) to 4(d)) which enabled rapid isolation of the effects of design variables. Based on the initial survey, 10 additional matrix points were added to indicate the desired configuration more clearly.



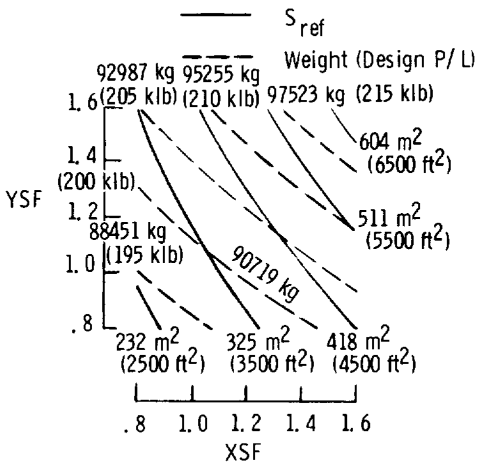
(a) Matrix of wings considered.

Figure 4.- Summary of geometric, weight, and aerodynamic characteristics. $\Lambda_{te} = 0^{\circ}$.

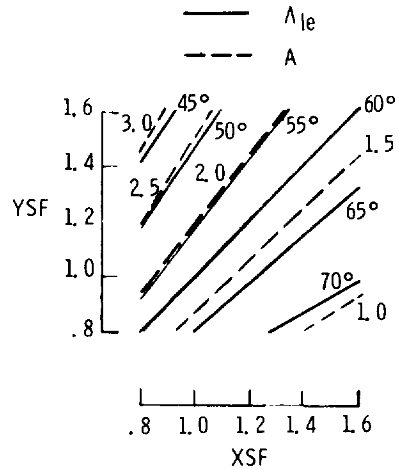
The entire 35 wing matrix calculations required approximately 1 hour of computer time. Individual assessment by conventional means was estimated conservatively to require one-half man-year.

Verification

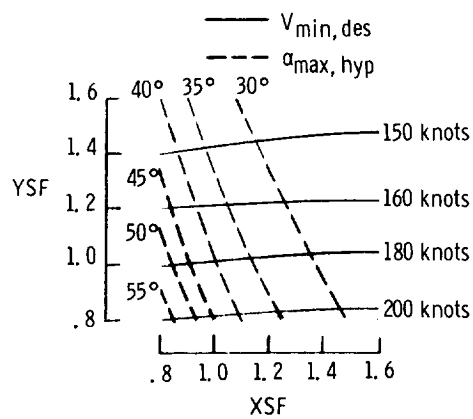
To complete the study cycle, models were constructed of the selected configuration to verify the estimated aerodynamic characteristics at both subsonic and hypersonic speeds. These models were then used to examine minor configuration improvements for



(b) S_{ref} and landed weight.



(c) Λ_{le} and A.



(d) $V_{min,des}$ and $\alpha_{max,hyp}$.

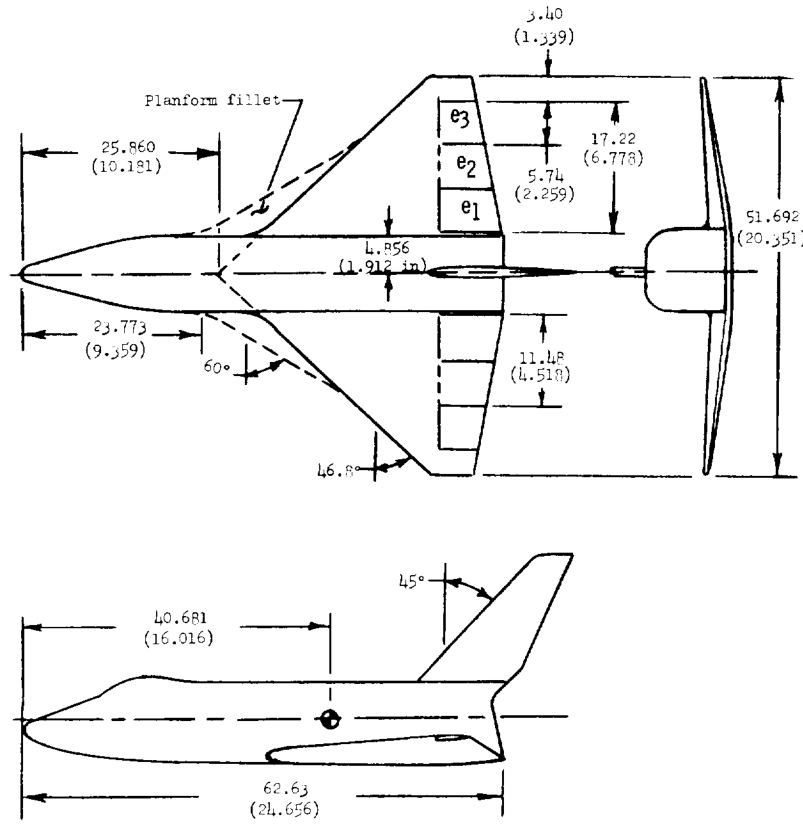
Figure 4.- Concluded.

which analytical techniques are inadequate. The following section entitled "Apparatus and Tests" is devoted to the introduction of the experimental aspects of the study.

APPARATUS AND TESTS

Subsonic

Model.- Details of the 0.01875-scale model used in the subsonic wind-tunnel design verification investigation are shown in figure 5(a). The model incorporated the analytically selected wing (W_{33} (Mod), table IV) mounted on a similarly scaled 040A fuselage. (See ref. 2.) The model wing had a leading-edge sweep angle of 46.8°, a trailing-edge sweep



(a) Subsonic model; BW_TV_2 (0.01875 scale); $S_{ref} = 0.11067\ m^2$;
$\Lambda_{le} = 46.8^{\circ}$; $\Lambda_{te} = -11.0^{\circ}$; $\lambda = 0.135$.

Figure 5.- Model schematic views. All dimensions are in centimeters (inches) unless otherwise specified.

of -11.0°, and an unswept elevon hingeline. The elevon tip chord was equal to 50 percent of the local wing chord. The basic (unfilleted) wing had an NACA 0008-64 airfoil section at the exposed root chord and varied linearly to an NACA 0012-64 section at the wing tip chord. Two basic wings identical in projected planform were utilized: a plane (untwisted) wing W_P with 1.5° incidence; and a twisted wing W_T having the same incidence at the exposed root chord and 4.5° washout. Trisegmented elevons were incorporated for the model wings. A 60° swept planform fillet could be added ahead of the wing leading edge. This fillet had a leading-edge radius of about 0.20 cm and a hand-faired section which was tangential with the basic wing section at the local maximum thickness stations. Addition of the wing fillet increased the exposed model wing area by about 8.5 percent.

TABLE IV.- SUMMARY DATA FOR SELECTED CONFIGURATION

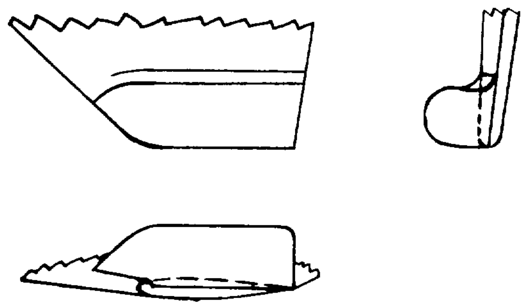
[ODIN summary data for W_{33} (Mod)]

Overall configuration:					
Area, planform, m^2 (ft^2)				378.0	(4069.3)
Length, nose to wing leading edge at body, cm (in.)				1655.32	(651.70)
Length, nose to wing $\bar{c}/4$, cm (in.)				2267.71	(892.80)
Fuselage:					
Area, wetted, m^2 (ft^2)				585.9	(6307.0)
Length, nose to end of body, cm (in.)				3340.1	(1315.0)
Wing:					
Area, theoretical or total, m^2 (ft^2)				314.67	(3387.1)
Area, elevon, m^2 (ft^2)				63.06	(678.75)
Span, cm (in.)				2756.9	(1085.4)
Chord, mean aerodynamic, cm (in.)				1362.76	(536.52)
Chord, center-line root, cm (in.)				2011.91	(792.09)
Chord, tip, cm (in.)				270.92	(106.66)
Taper ratio, theoretical					0.13465
Aspect ratio, theoretical					2.4154
Aspect ratio, exposed span					2.2896
Angle, leading-edge sweep, deg					46.825
Angle, trailing-edge sweep, deg					-11.0
Angle, dihedral, deg					7.0
Angle, incidence, deg					1.5
Airfoil section, root					NACA 0008-64
Airfoil section, tip					NACA 0008-64

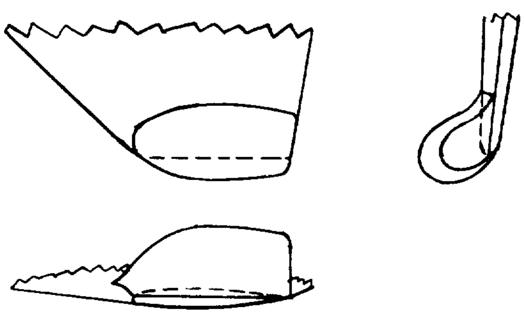
Mass properties at flight condition:	Weight, kg	Weight, (lb)	x_{cg}, m	x_{cg}, (ft)	x_{cg}/l, percent
Orbiter landing (Design P/L)	90 541	(199 609)	21.7	(71.181)	64.96
Orbiter landing (P/L out)	72 397	(159 609)	22.41	(73.523)	67.096
Wing weight	7473.80	(16 476.8)			
Thermal protection system weight	12 258.96	(27 926.2)			

Principal parameters:		
x-scale factor, XSF		0.80000
y-scale factor, YSF		1.3000
Distance to leading edge of exposed wing, x_{wing}, cm (in.)	1655.31	(651.70)
Landing performance:		
Minimum landing speed (Design P/L), knots		150.2
Static margin (subsonic) (Design P/L)		0.0804
Static margin (subsonic) (P/L out)		0.0280
Trim C_L for landing ($\alpha = 17^{\circ}$)		0.7715
Hypersonic aerodynamic trim data:		
Trim angle of attack at elevon -45°, deg		45.59

The vertical tail V_2 (ref. 2) had NACA 0012-64 airfoil sections. Semifaired and fully tailored wing-tip-mounted ACPS pods were included as model configuration variables P_1 and P_2, respectively. These pods were sized to represent the scaled volumetric requirement of the ACPS roll control. (See fig. 5(b).)



Semifaired pods, P_1
Volume (2 pods) = 31.0 cm^3



Fully tailored pods, P_2
Volume (2 pods) = 31.0 cm^3

(b) Wing tip roll ACPS pods (0.01875-scale model).

Figure 5.- Continued.

Tunnel.- Subsonic tests were conducted in the Langley low turbulence pressure tunnel which is a variable-pressure, single-return facility with a closed test section 0.914 meter (3.0 feet) wide and 2.29 meters (7.5 feet) high. The tunnel is a low subsonic facility ($M \leq 0.4$) with the capability of Reynolds numbers per unit length up to about 49.2×10^6 per meter (15.0×10^6 per foot).

Test conditions.- The investigation was conducted at a Mach number of about 0.25 and at Reynolds numbers from about 12.6×10^6 to 21.0×10^6, based on the fuselage length. Test angle of attack was varied from approximately -3° to 20° at 0° sideslip.

Measurements and corrections.- An internally mounted six-component strain-gage balance was used to measure aerodynamic forces and moments acting on the model. No base- or chamber-pressure corrections were applied to the data. Corrections have been applied to the angles of attack and sideslip to account for sting and balance deflections produced by aerodynamic load on the model. All pitching-moment coefficient data are presented about the moment reference point location shown in figure 5(a) unless otherwise specified. The subsonic longitudinal aerodynamic coefficients and angles of attack have been corrected for blockage and lift interference in accordance with the techniques outlined in references 6 and 7.

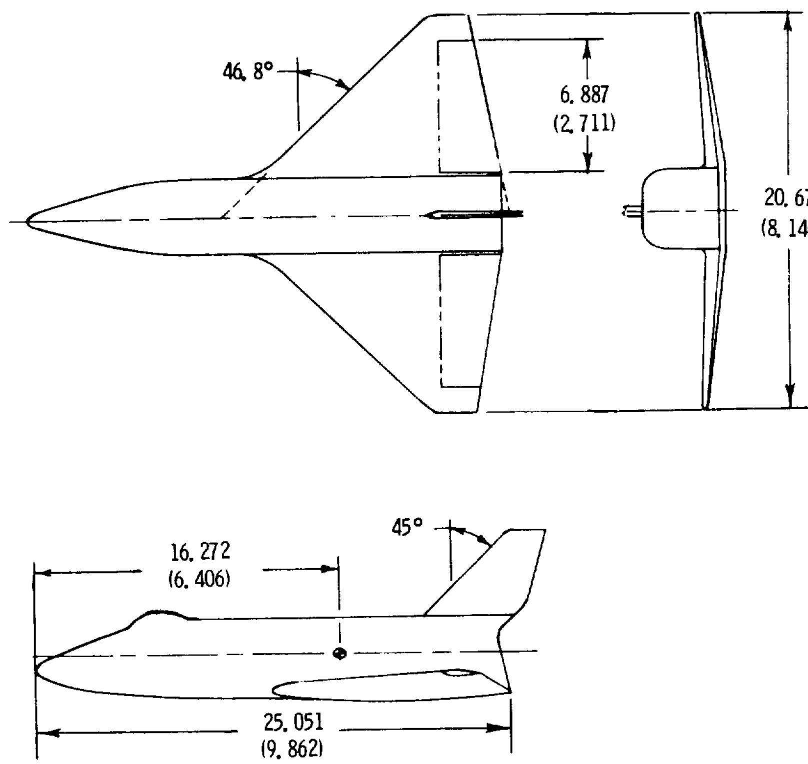
Hypersonic

Model.- The hypersonic model was a 0.0075-scale model of the analytically selected configuration and is shown in figure 5(c). The model wing geometric features were similar to the subsonic plane (untwisted) model wing. The vertical tail V_1 was geometrically similar in planform to the 040A vertical tail V_1 (ref. 2) and used NACA 0012-64 airfoil sections.

Tunnel.- The hypersonic tests were made in the Langley continuous-flow hypersonic tunnel, which is designed to operate over a pressure range of 15 to 150 atmospheres (1 atmosphere = 101 325 N/m^2) at temperatures up to 1090 K (1960° R). Air is heated by an electrical resistance multitube heater prior to entry into a water-cooled contoured nozzle which has a 79-cm-square (31-inch-square) test section. Continuous operation is achieved by recirculating the air flow through a series of compressors. Reynolds number varies from 1.64×10^6 to 8.53×10^6 per meter (0.5×10^6 to 2.6×10^6 per foot).

Test conditions.- The hypersonic tests were conducted at a Mach number of about 10.3, a stagnation pressure of about 50 atmospheres, and a test Reynolds number of about 0.8×10^6 based on the fuselage length. Data were taken at angles of attack from approximately 15° to 48° at 0° sideslip.

Measurements and corrections.- Aerodynamic force and moment data were measured by an internally mounted six-component strain-gage balance. The balance was strut mounted on an injection system assembly which inserted the model into the airstream.



(c) Hypersonic model; BW_pV_1 (0.0075 scale); $S_{ref} = 0.1771\ m^2$;
$\Lambda_{le} = 46.8^o$; $\Lambda_{te} = -11.0^o$; $\lambda = 0.135$.

Figure 5.- Concluded.

Balance temperatures were continuously monitored to allow model retraction prior to overheating of the components. Angles of attack have been corrected to account for sting and balance deflections produced by aerodynamic loading. No base- or chamber-pressure corrections were applied to the data. The pitching-moment coefficient data are presented about the moment reference point location shown in figure 5(c).

RESULTS AND DISCUSSION

Analytical Results

Effect of wing geometry on aerodynamics, weight, and performance.- Summary results from the initial 25-wing matrix ($\Lambda_{te} = 0^o$) are shown in figure 4 and in the appendix.

The resulting configuration geometries, curves of constant landed weight, wing reference area, aspect ratio, leading-edge sweep, minimum design speed, and maximum hypersonic trim angle of attack are presented in figure 4. In order to satisfy the guidelines of the study, a wing is required to have the geometry specified at or above and to the left of the intersection of the 150-knot $V_{min,des}$ curve with the curve for a hypersonic trimmed α_{max} of 50^{o}. This projected intersection would occur at values of XSF and YSF of about 0.75 and 1.4, respectively, which represents an $A > 3.0$ wing configuration having a leading-edge-sweep angle less than 45^{o}. (See fig. 4(b).) Entry heating considerations, however, which were used to establish the 45^{o} minimum wing sweep boundary of table I precluded the further consideration of the aerodynamically desirable wing configurations indicated in figure 4. The nearby region containing wings having leading-edge sweep angles of 45^{o} or greater was then investigated since it should contain the wing configurations most nearly conforming with the established guidelines and constraints. For this purpose 10 additional wing configurations were added to the initial matrix. Summary data for these additional configurations are presented in the appendix.

Effect of elevon size and Λ_{le}.- Figure 6 shows the effect of elevon chord increases on the hypersonic trim capability of the orbiter wings included in the study matrix. These results indicate that increasing the elevon area by about 4 percent of the wing area increases the maximum hypersonic trim angle from 6^{o} to 8^{o} for wings having reference areas between 210 and 330 m^2 (2260 and 3552 ft^2). Figure 7 shows the effect of leading-edge sweep angle on the subsonic minimum design speed. The lower sweep angles allow the smaller wing areas to meet the subsonic requirement for a minimum design speed of 150 knots. In addition, reduced wing areas yield increased hypersonic trim angle-of-attack capability as indicated in figure 6.

Configuration selection.- Two configurations W_{27} and W_{33} (see appendix) were selected from the study matrix for further analysis. These configurations exhibited values of XSF and YSF indicated in figure 4 and would most likely result in wing planforms capable of meeting the subsonic-hypersonic criteria without violating the 45^{o} minimum sweep constraint. The configuration W_{27} is defined in the appendix for values of XSF and YSF of 0.9 and 1.3 and configuration W_{33} by XSF and YSF values of 0.8 and 1.3. These two configurations were selected since each was considered to be marginally acceptable in satisfying the guidelines of the study regarding hypersonic trim and minimum design speed. As indicated in the index in the appendix (table V), $V_{min,des}$ for W_{27} and W_{33} were 151 knots and 154 knots, respectively. Also indicated are maximum

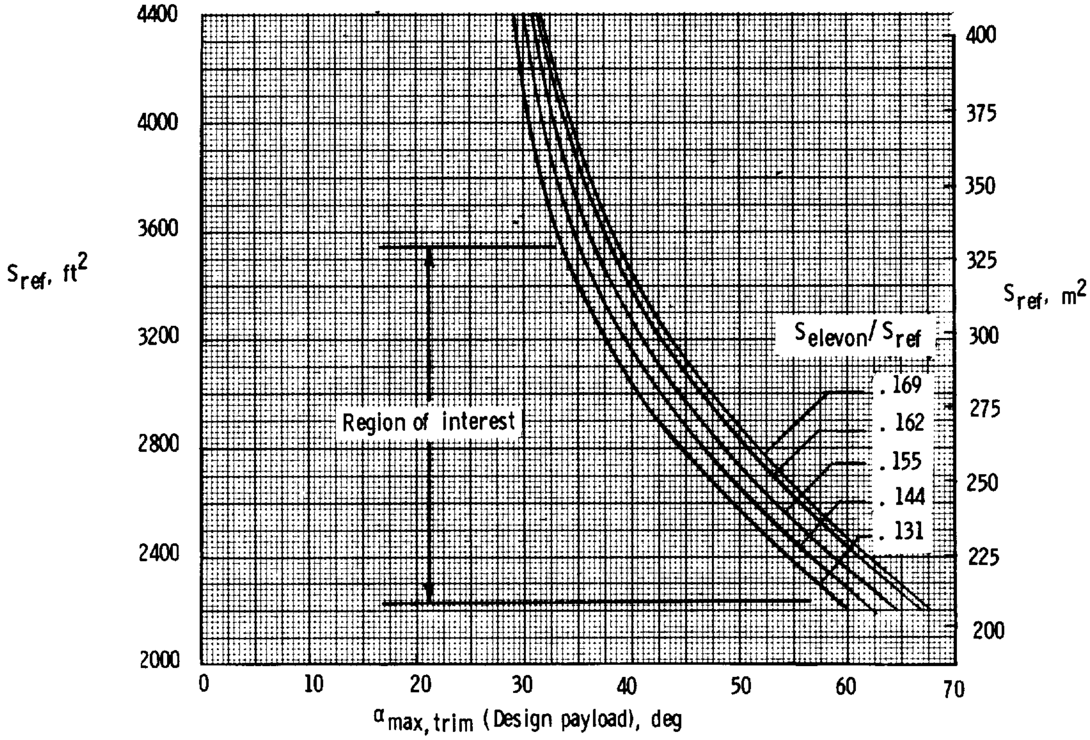


Figure 6.- Analytical effects of elevon size at hypersonic speeds for study wings. $\Lambda_{te} = 0^{\circ}$.

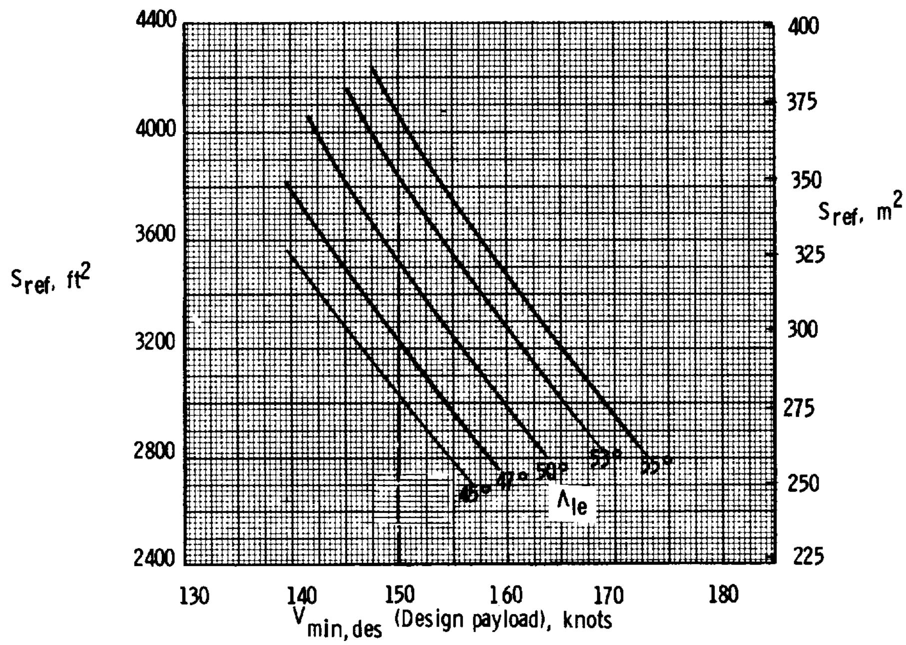
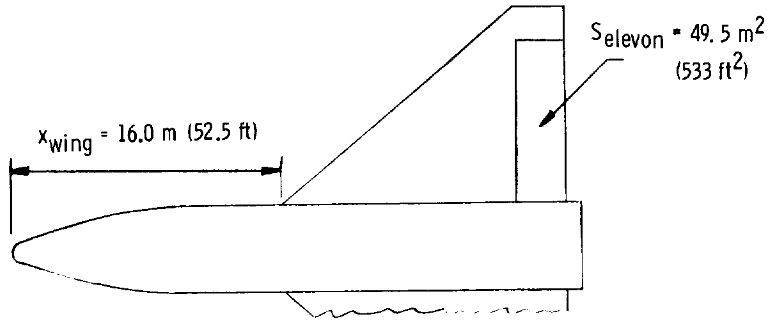


Figure 7.- Analytical effect of leading-edge sweep angle.

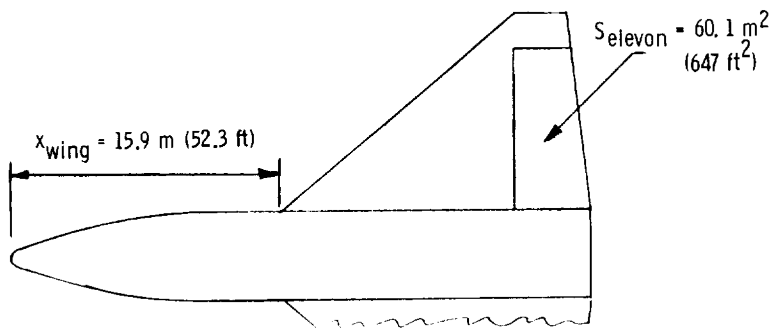
hypersonic trim angles of 40° and 46°, respectively, for the two configurations. At this point in the design cycle, improvements in the analytical aerodynamic characteristics as well as the introduction of empirical or experience factors are required to insure experimental compliance of the selected configurations with the established aerodynamic guidelines. For example, past comparisons with experiment have indicated higher analytical values of subsonic C_L and hypersonic trim capability (ref. 8) than experimental results for delta wings of moderate aspect ratio and sweep.

Reduction of $V_{min,des}$ to the 150-knot guideline value requires an increase in wing area for both configurations (W_{27} and W_{33}); hypersonic trim requirements, on the other hand, dictated a decrease in wing area or that the wing be moved forward to reduce the level of longitudinal stability. The subsonic stability criteria constrained the forward wing movement for both wings and thereby precluded meeting the hypersonic trim guidelines.

A possible solution to these conflicting requirements would be to increase the wing area slightly by using a negatively swept trailing edge and move the wing forward to comply with subsonic stability requirements and to achieve increased hypersonic trim capability. Additional benefits in hypersonic trim might also be realized by retaining the present elevon hingeline locations relative to the exposed wing to provide increased movable elevon areas. The effects of these modifications on wings W_{27} and W_{33} are shown in figures 8 and 9, respectively. Analytical results for the W_{27} modification indicate that the target $V_{min,des}$ of 150 knots was achieved, whereas the hypersonic $\alpha_{max,\,trim}$ increased by only 1° to a value of 41°. Since the wing-forward movement was very slight, the corresponding increase in hypersonic trim angle was extremely small. (Compare fig. 8(a) with fig. 8(b).) Comparison of figure 9(a) with figure 9(b) shows that these modifications of W_{33} produced more desirable results. The value of $V_{min,des}$ for the modified wing was reduced to 150 knots whereas hypersonic trim capability was extended to 49°. This wing configuration was selected for the experimental verification with one further modification; the elevon chords were arbitrarily reduced to improve structural integrity of the wing tips. The resulting configuration selected is shown in figure 10 and pertinent summary characteristics are shown in table IV. The analytical results indicated that the selected configuration met all the aerodynamic design requirements outlined in table I with the exception of the maximum angle-of-attack hypersonic trim. Because of the reduced elevon area, the design exhibited a maximum trimmed angle of attack 4° less than the required value (50°). This deficiency could be eliminated



(a) $\Lambda_{te} = 0^{\circ}$; W_{27}; $V_{min,des}$ (Design P/L) = 151 knots; hypersonic $\alpha_{max,trim}$ (Design P/L) = 40°; S_{ref} = 312 m^2 (3357 ft^2).



(b) $\Lambda_{te} = -7.0^{\circ}$; W_{27} (Mod); $V_{min,des}$ (Design P/L) = 150 knots; hypersonic $\alpha_{max,trim}$ (Design P/L) = 41°; S_{ref} = 328 m^2 (3535 ft^2).

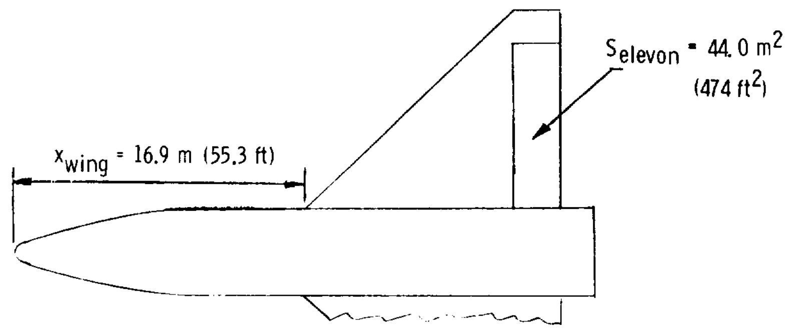
Figure 8.- Effect of trailing-edge sweep angle on wing W_{27}. $\Lambda_{le} = 50.2^{\circ}$.

by some fuselage nose reshaping (not considered in the wing study) which has been shown to provide a positive increment in pitching moment. (See ref. 9.)

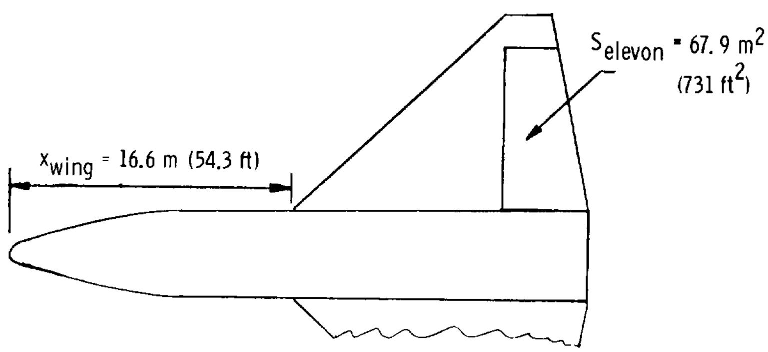
Subsequent experimental wind-tunnel studies using the selected configuration were made to validate these aerodynamic estimates and to demonstrate the aerodynamic development required to produce a satisfactory orbiter design.

Experimental Results

The basic longitudinal aerodynamic data obtained at subsonic and hypersonic speeds for the selected configuration are presented. The subsonic data are shown in figures 11



(a) $\Lambda_{te} = 0^o$; W_{33}; $V_{min,des}$ (Design P/L) = 154 knots; hypersonic $\alpha_{max,trim}$ (Design P/L) = 46°; S_{ref} = 315 m^2 (2983 ft^2).



(b) $\Lambda_{te} = -11.0^o$; W_{33} (Mod); $V_{min,des}$ (Design P/L) = 150 knots; hypersonic $\alpha_{max,trim}$ (Design P/L) = 49°; S_{ref} = 315 m^2 (3387 ft^2).

Figure 9.- Effect of trailing-edge sweep angle on wing W_{33}. $\Lambda_{le} = 46.8^o$.

to 17 with hypersonic data in figure 18. The subsonic aerodynamic characteristics of the configuration selected are summarized in figures 19 to 22. Longitudinal aerodynamic characteristics obtained at hypersonic speeds are summarized in figure 23.

Subsonic analytical and experimental comparisons.- A comparison of the analytical predictions with subsonic longitudinal aerodynamic characteristics obtained at high Reynolds number ($R_l \approx 20 \times 10^6$) in the Langley low turbulence pressure tunnel is shown in figure 19. The wind-tunnel and analytical data are in good agreement at low to moderate angles of attack. The pitch-down tendency which occurs at high angles of attack in the

Λ_{le} = 46.8°
Λ_{te} = -11.2°
S_{ref} = 315 m^2 (3387 ft^2)
S_{elevon} = 63.1 m^2 (679 ft^2)
λ = .135
A = 2.4
i_{wing} = 1.5°

Payload out:
Landed weight = 72398 kg (159609 lb)
x_{cg} = 0.671l
$C_{m_{C_L}}$ = -0.028 $\bar{c}$

Design payload:
Landed weight = 90542 kg (199609 lb)
x_{cg} = 0.650l
$C_{m_{C_L}}$ = -0.080 c
$V_{min,des}$ (α = 17°) = 150 knots
$\alpha_{max,trim}$ at hypersonic speeds = 46°

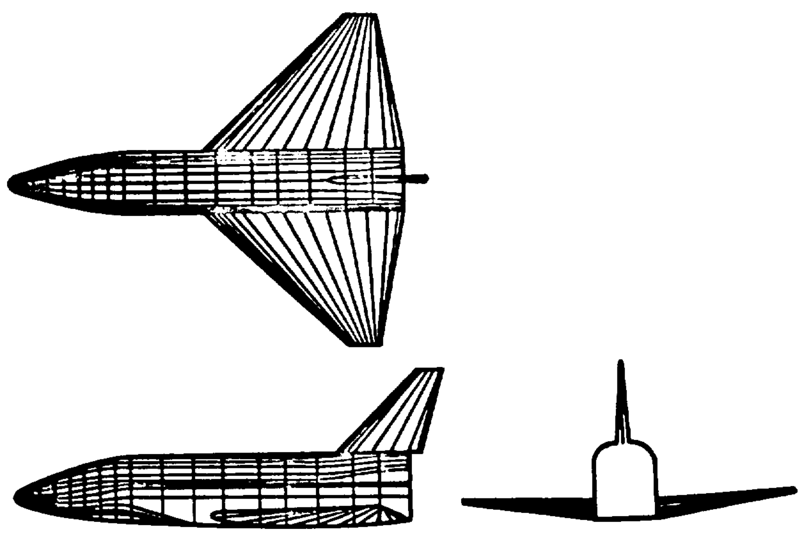


Figure 10.- Configuration selected, W_{33} (Mod).

experimental data was not predicted analytically because linear trends were assumed. This tendency reduces trimmed lift coefficient at high angles of attack below the level predicted and would result in an increase in minimum design speed of 12 knots for the design payload condition.

<u>Effect of planform fillet on subsonic characteristics.</u>- In an attempt to alleviate the landing lift decrement, a wing leading-edge planform fillet was added to the subsonic model (figs. 5(a) and 20). The fillet provided sufficient lift at the higher angles of attack

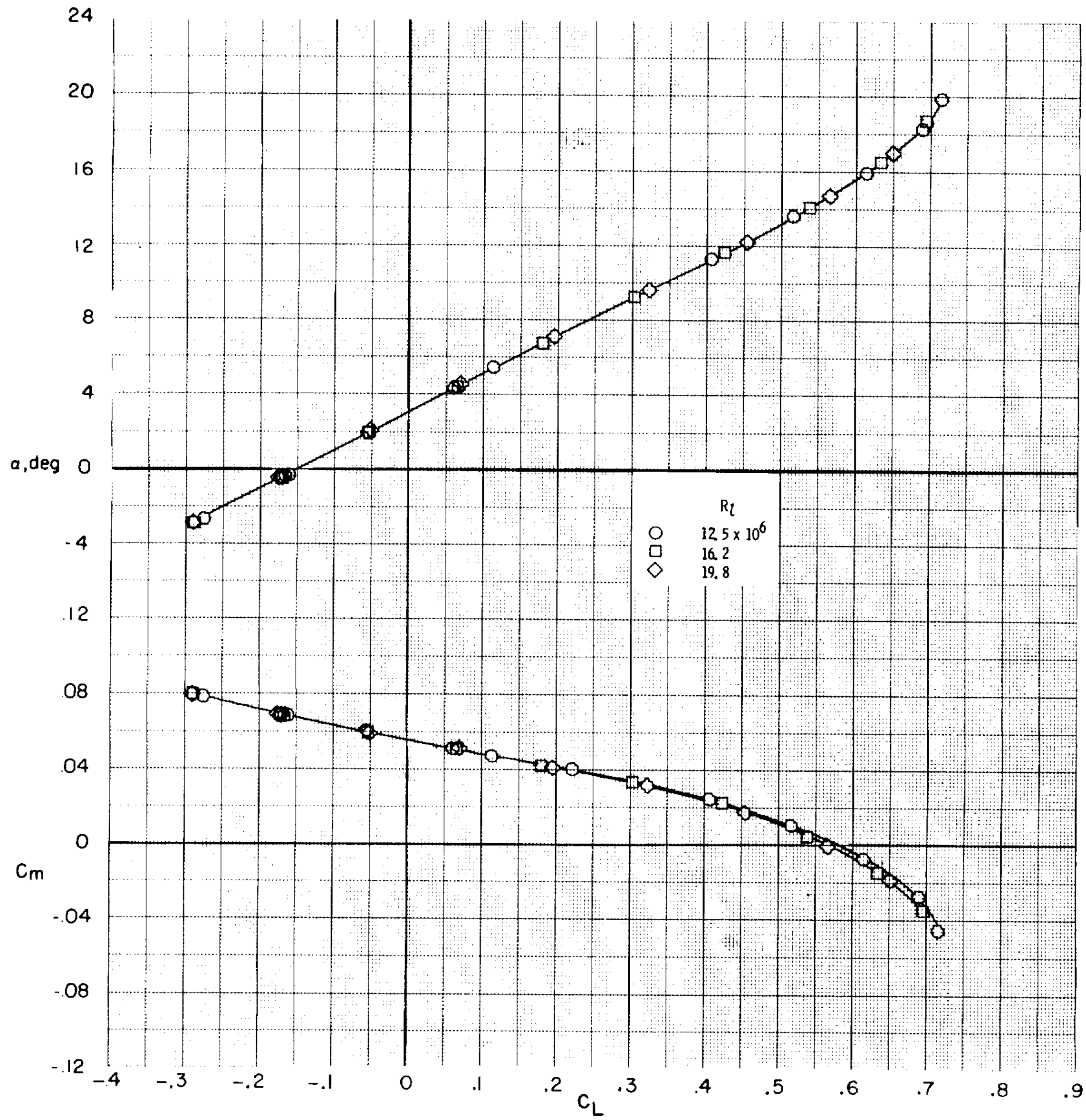


Figure 11.- Effect of Reynolds number on the longitudinal aerodynamic characteristics of the untwisted wing configuration BW_PV_2. $\delta_{e_1} = \delta_{e_2} = \delta_{e_3} = -10^{\circ}$.

to linearize the trimmed lift curve and provide a minimum design speed of about 150 knots. The addition of the fillet shifted the aerodynamic center of the configuration about $0.05\bar{c}$ forward and required a rearward shift of the wing of about the same amount to keep the static margin of the configuration (payload out) at $0.03\bar{c}$.

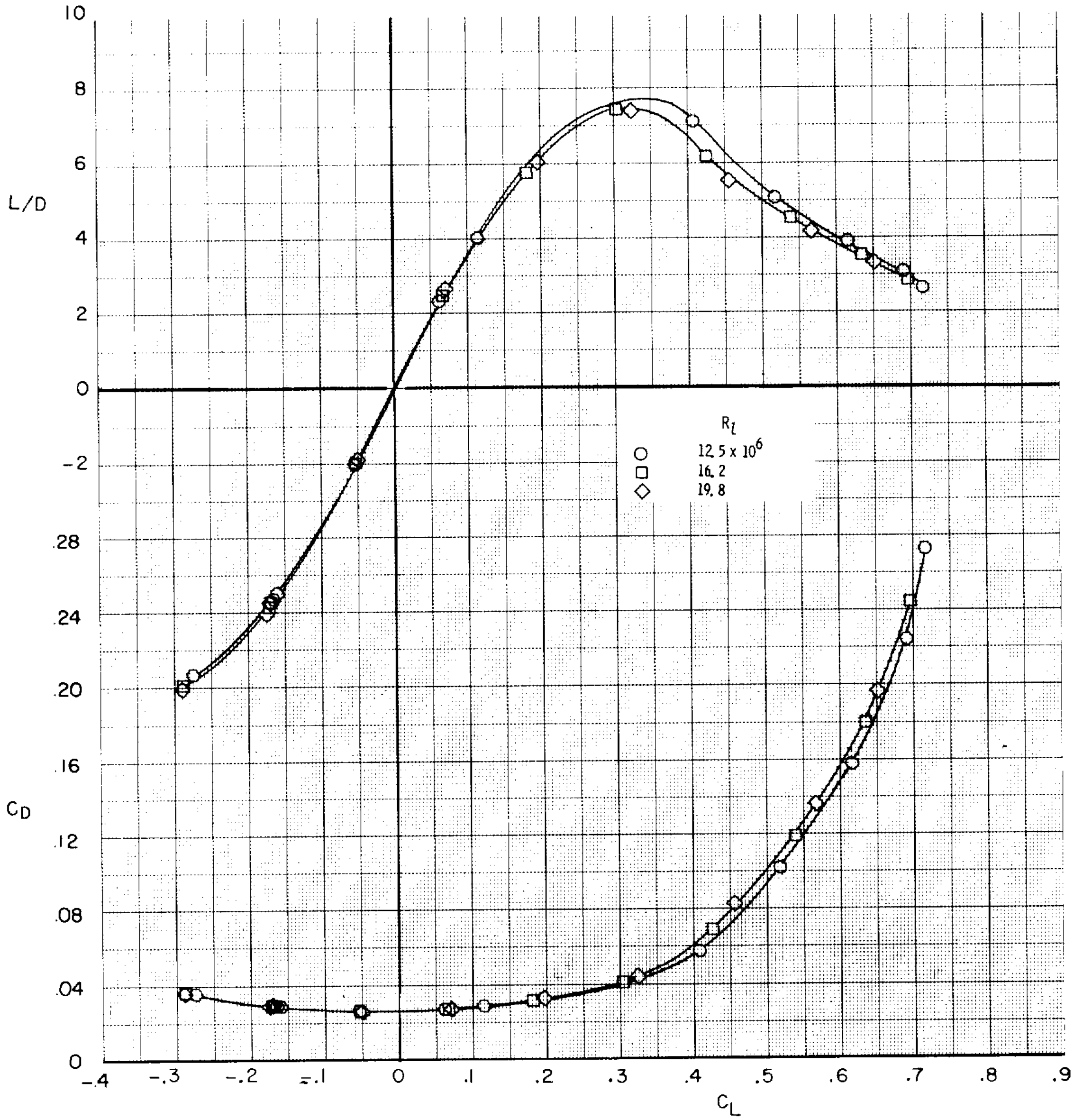


Figure 11.- Concluded.

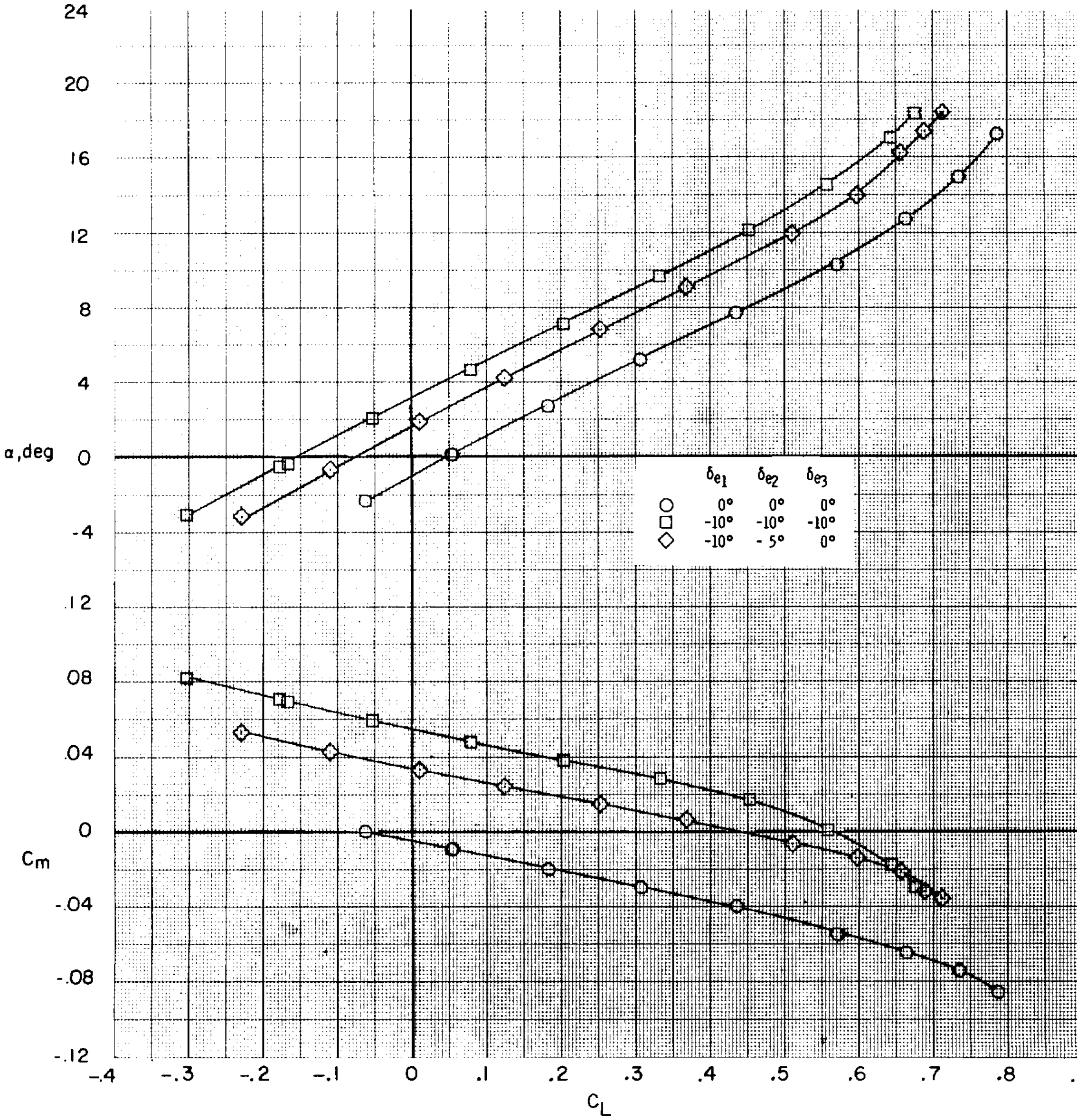


Figure 12.- Comparative longitudinal trim effects of unsegmented and segmented elevons for the untwisted wing configuration BW_pV_2. $R_l \approx 20.1 \times 10^6$.

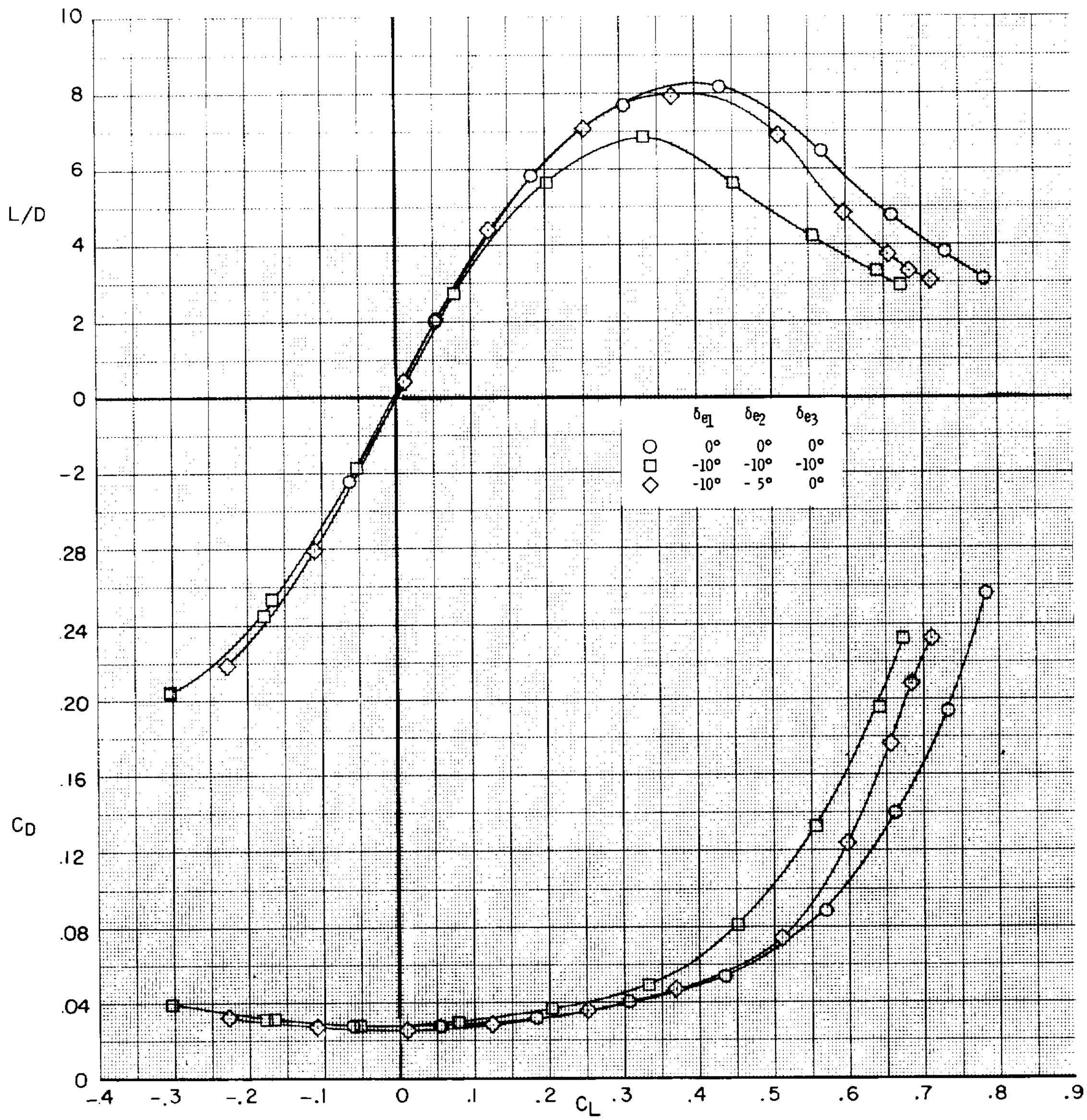


Figure 12.- Concluded.

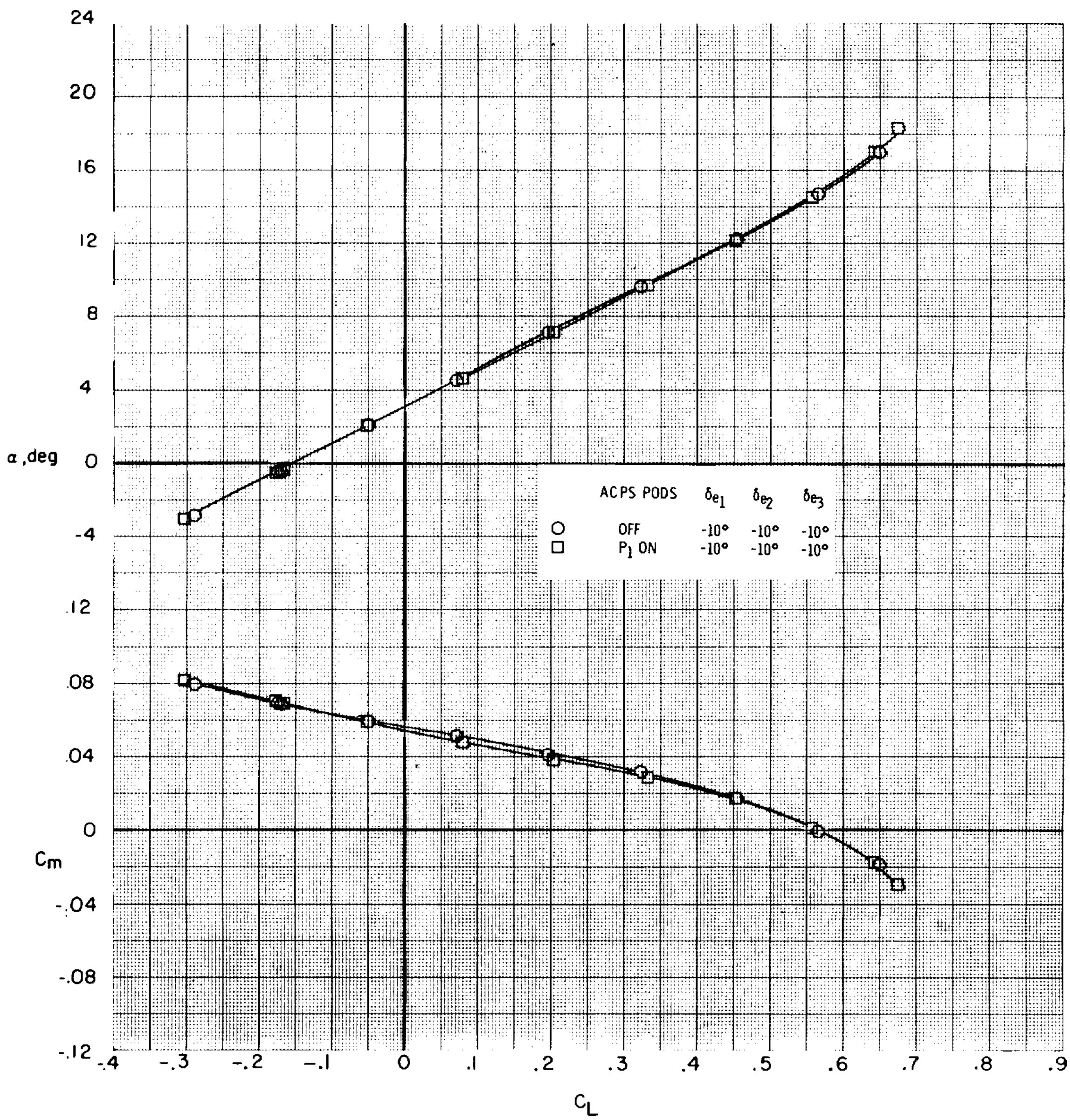


Figure 13.- Effect of adding ACPS pods P_1 on the aerodynamic characteristics of the untwisted wing configuration BW_PV_2. $R_l \approx 20.0 \times 10^6$.

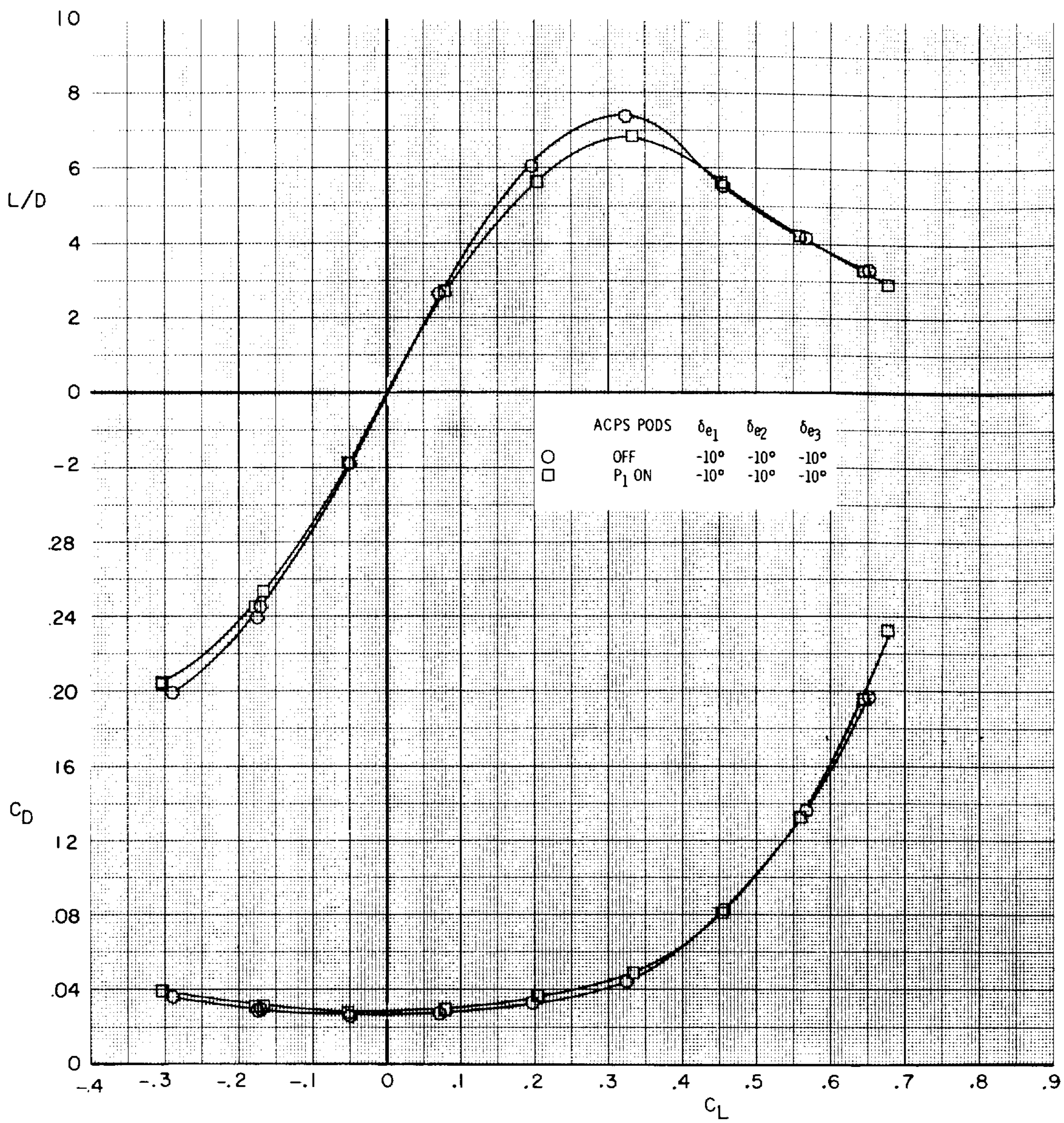


Figure 13.- Concluded.

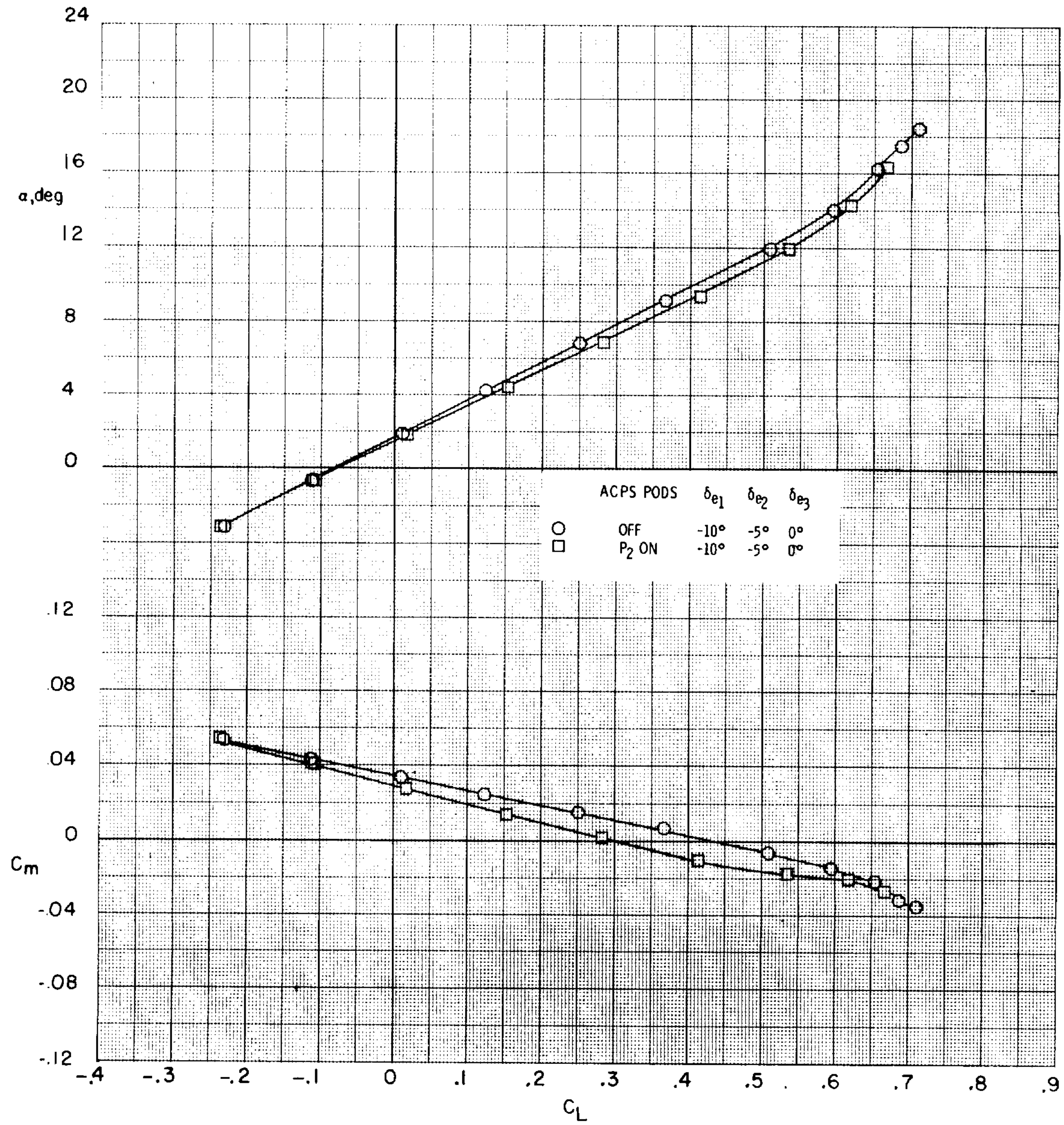


Figure 14.- Effect of adding contoured ACPS pods P_2 on the aerodynamic characteristics of the untwisted wing configuration BW_PV_2. $R_l \approx 20.3 \times 10^6$.

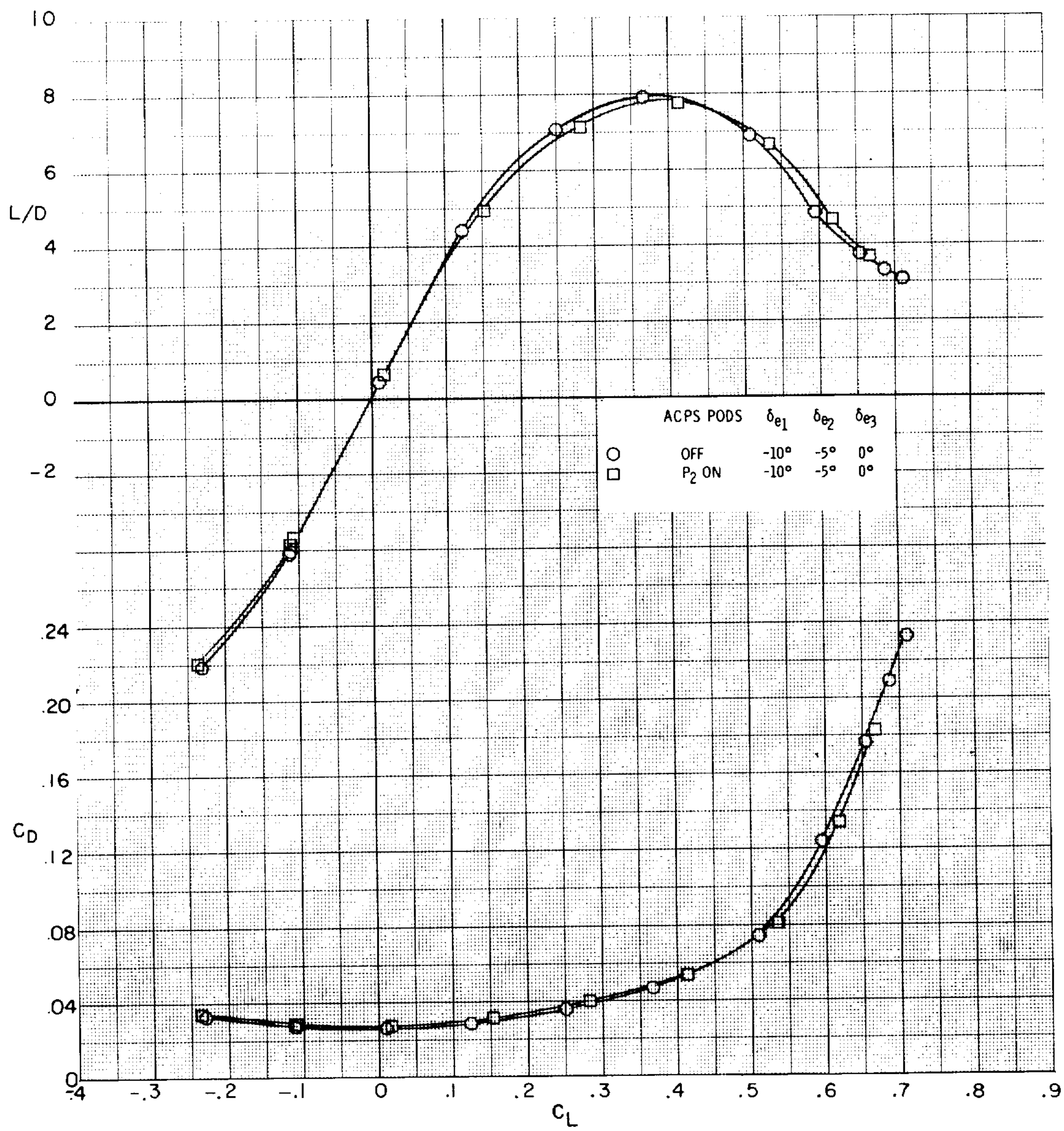


Figure 14.- Concluded.

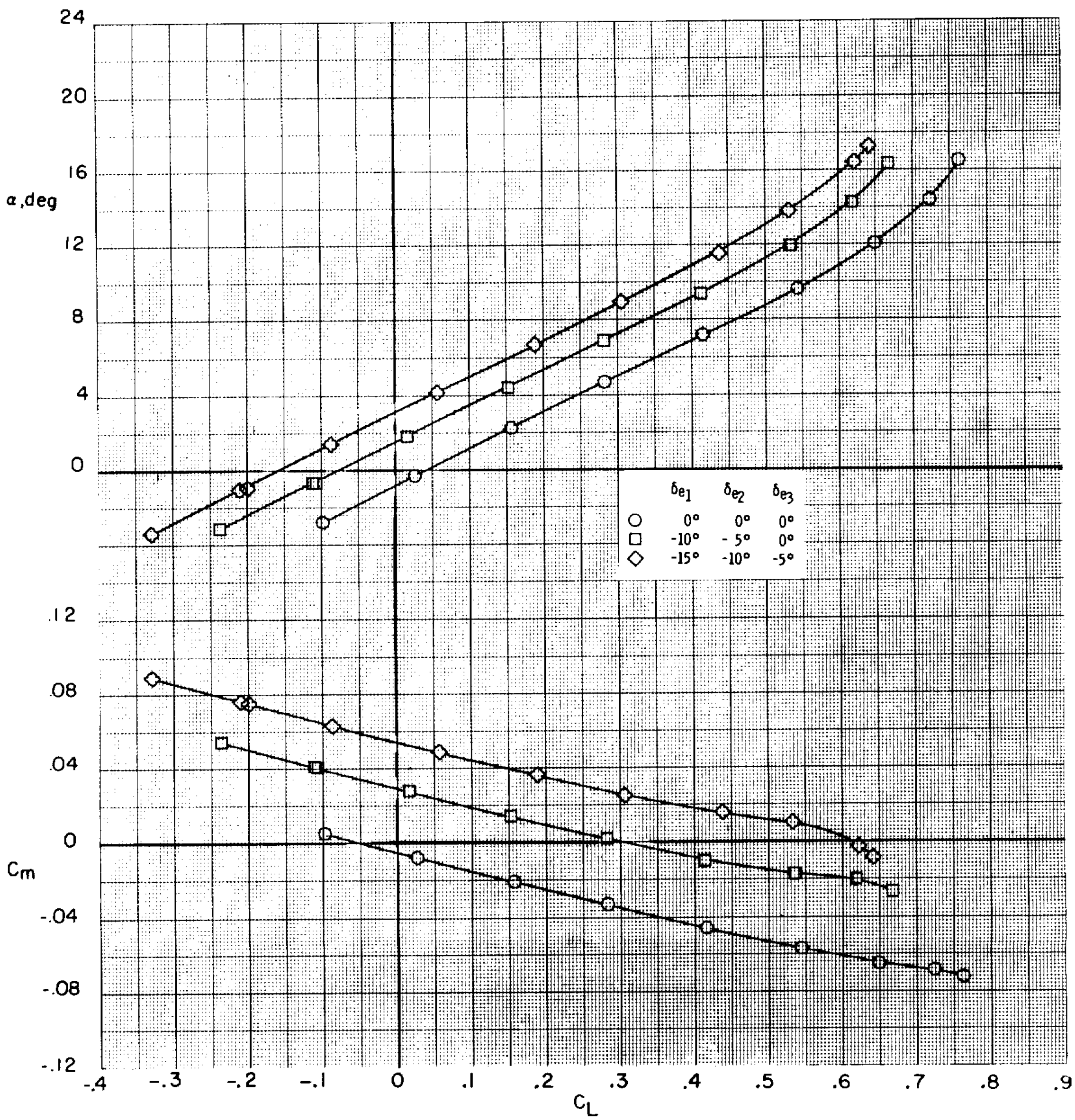


Figure 15.- Effect of segmented elevon deflections on the longitudinal aerodynamic characteristics of the untwisted wing configuration with ACPS pods P_2 on. $BW_PV_2P_2$; $R_l \approx 20.6 \times 10^6$.

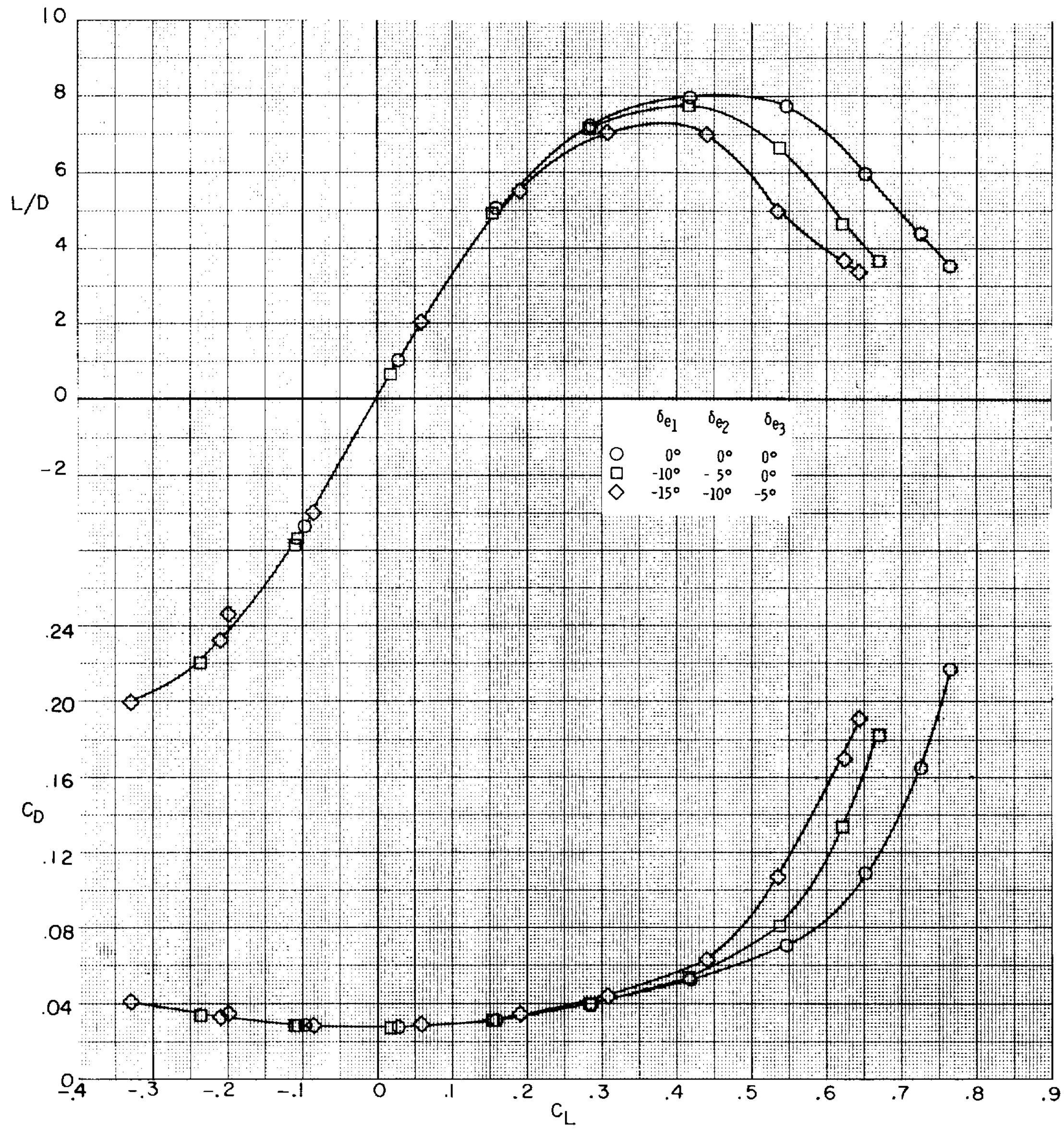


Figure 15.- Concluded.

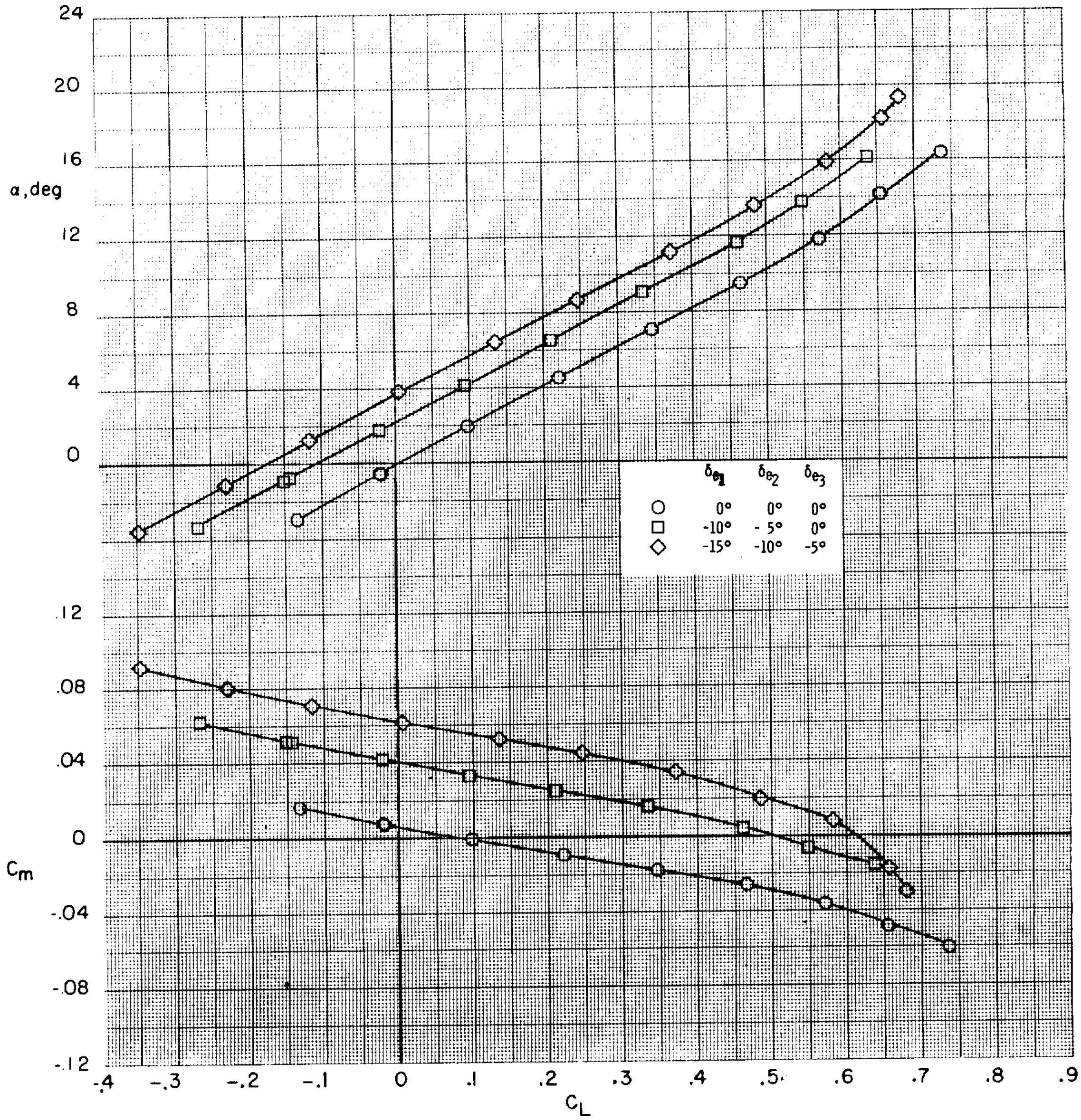


Figure 16.- Effect of segmented elevon deflections on the longitudinal aerodynamic characteristics of the twisted wing configuration BW_TV_2. $R_l \approx 20.1 \times 10^6$.

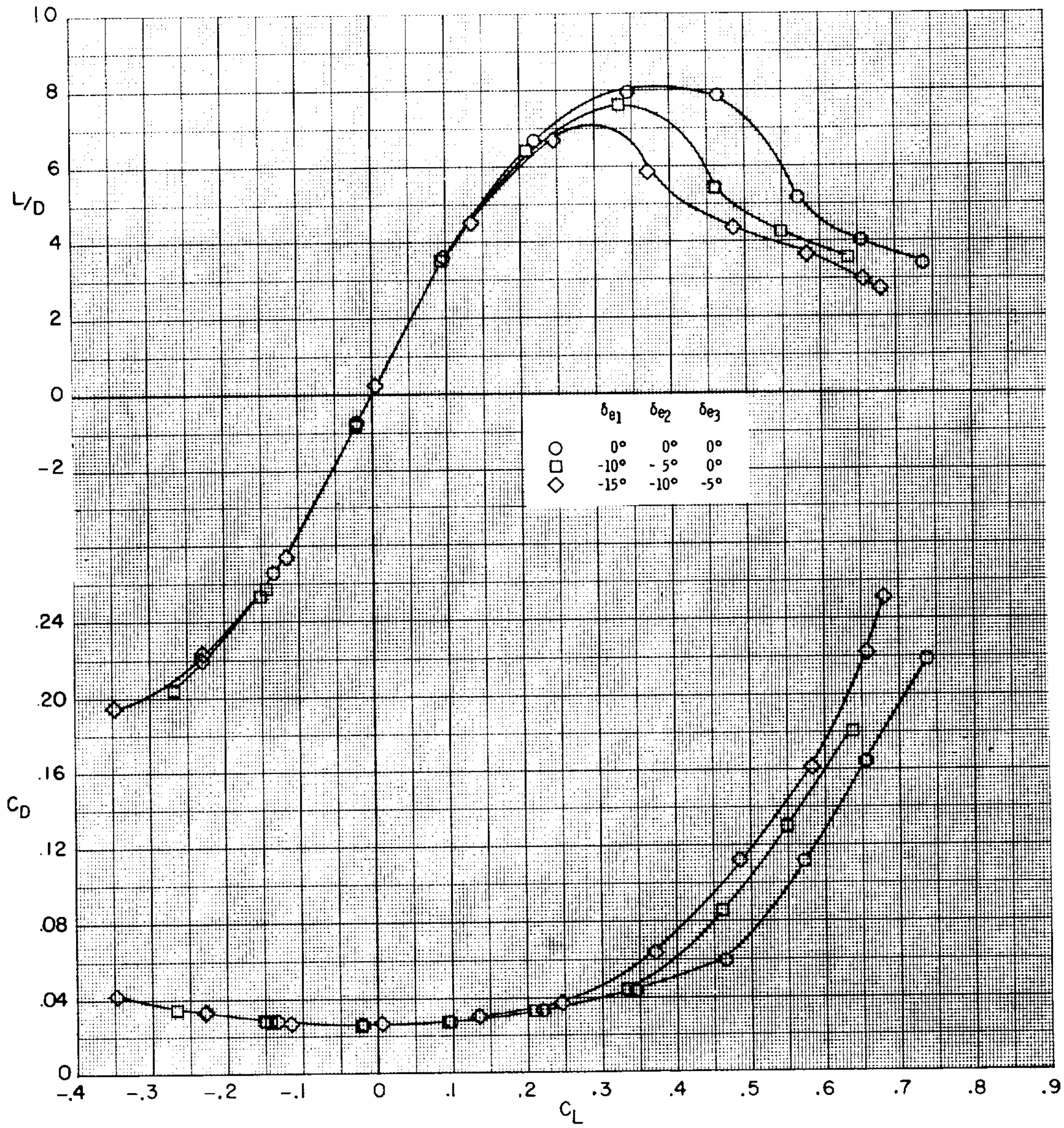


Figure 16.- Concluded.

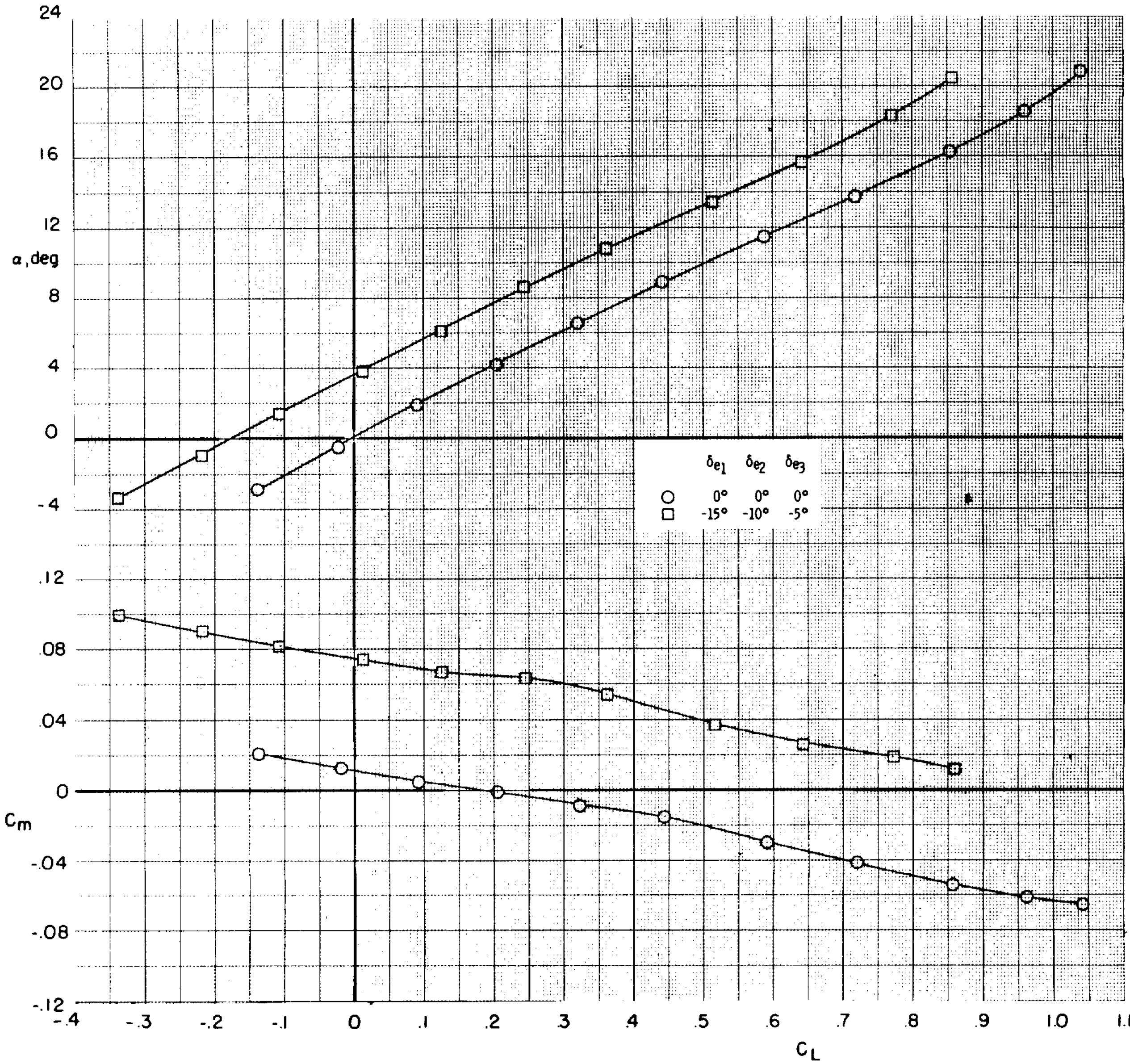


Figure 17.- Effect of segmented elevon deflections on the longitudinal aerodynamic characteristics of the twisted wing configuration with a planform fillet. BW_TV_2F; $R_l \approx 13.4 \times 10^6$.

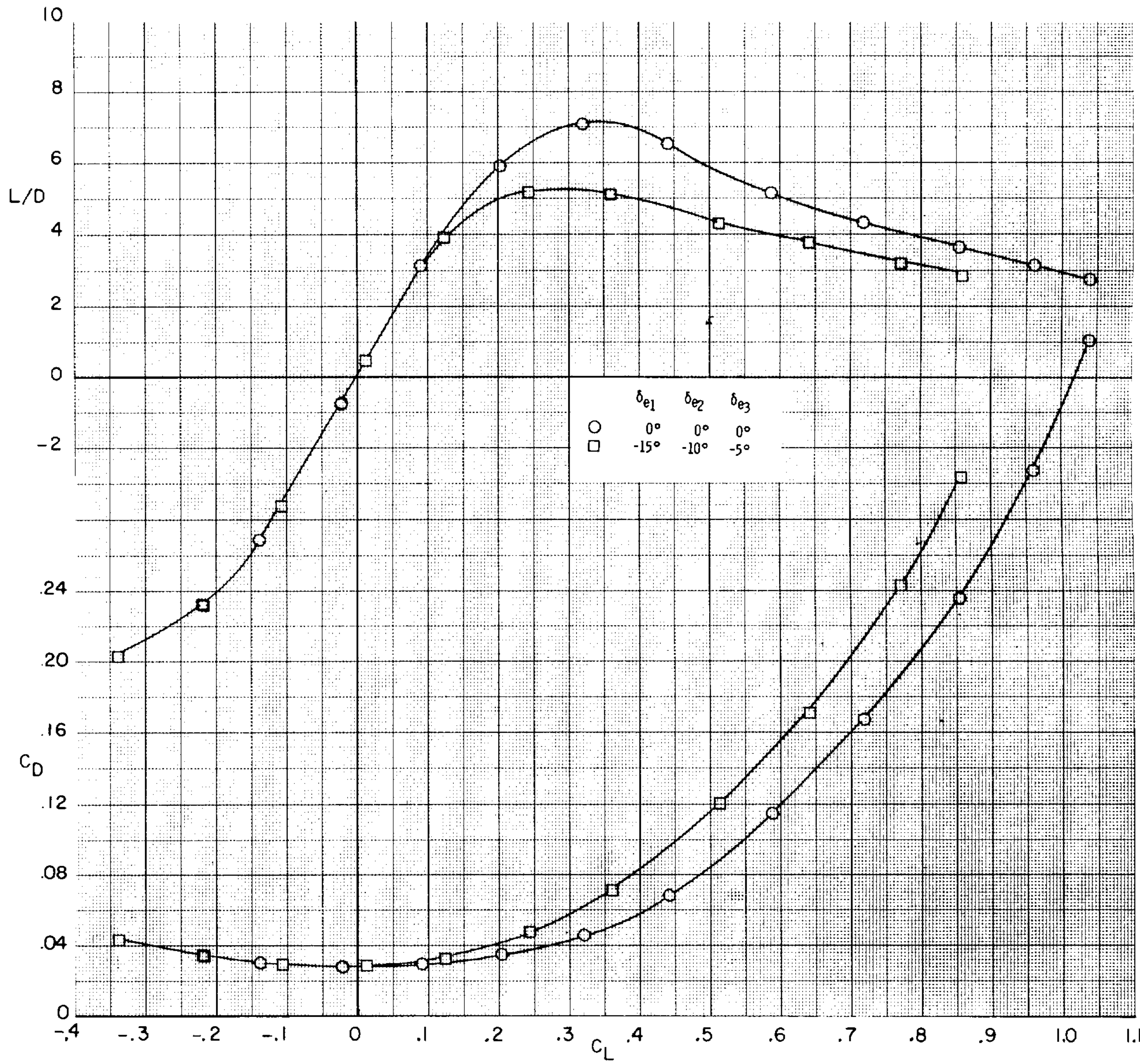


Figure 17.- Concluded.

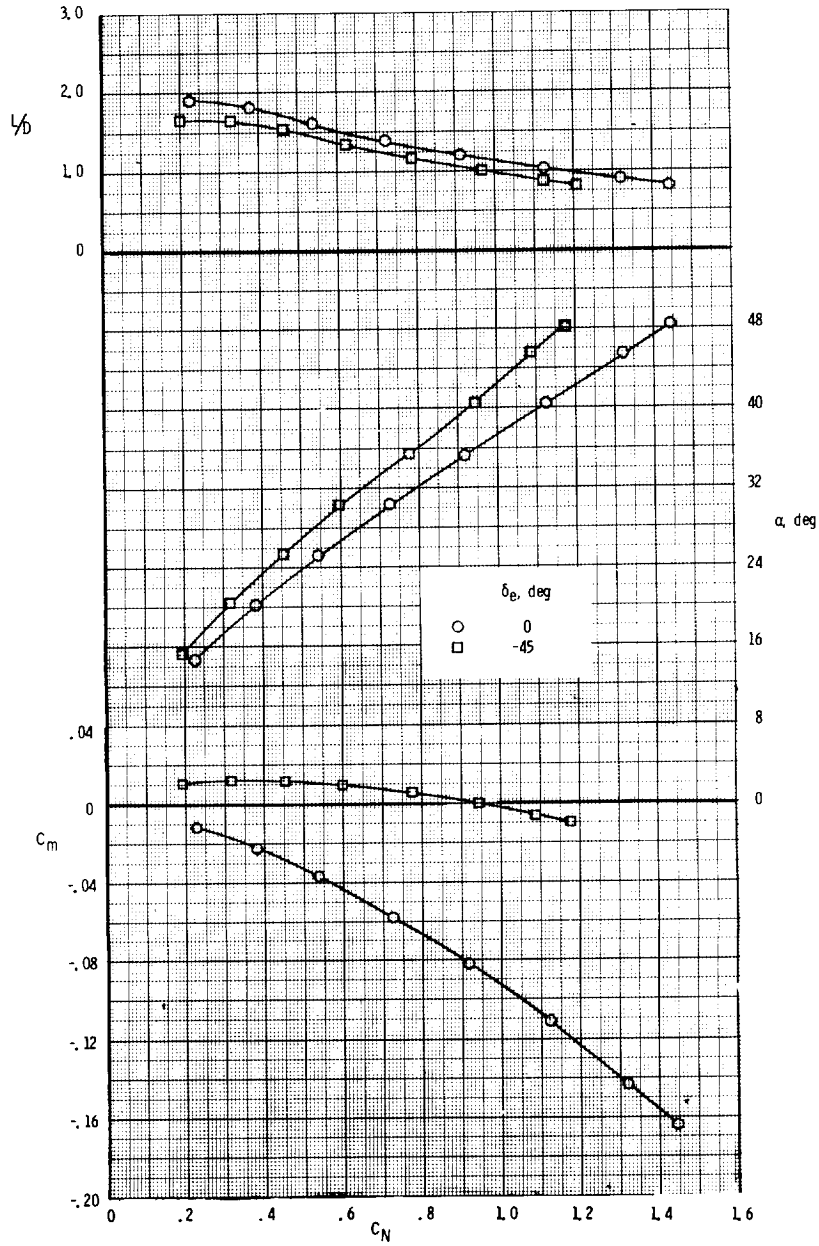


Figure 18.- Hypersonic aerodynamic characteristics for configuration BW_PV_1. M = 10.33.

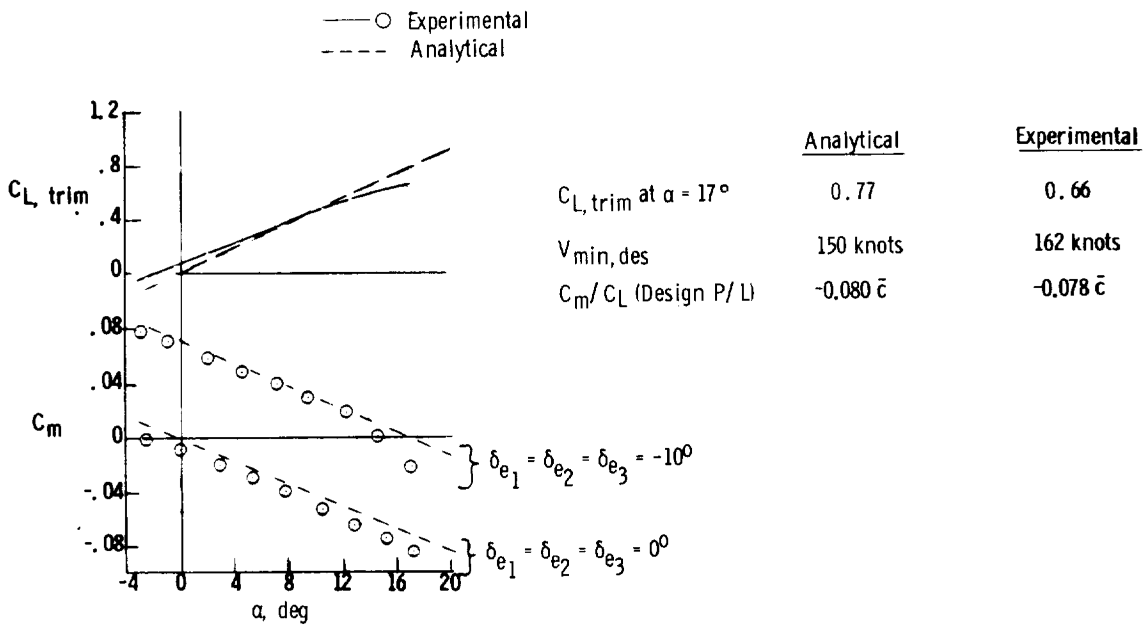


Figure 19.- Comparison of subsonic analytical aerodynamic characteristics with wind-tunnel experimental values for configuration BW_PV_2.

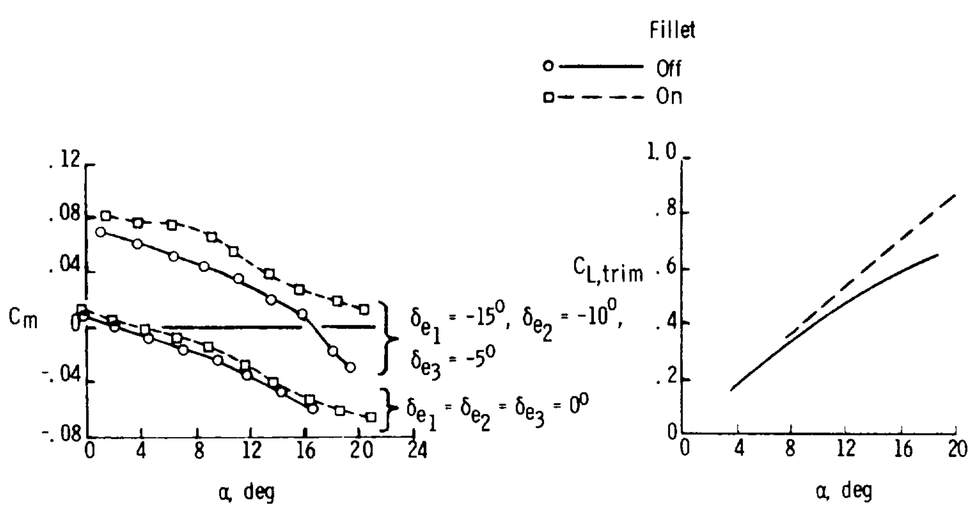


Figure 20.- Effect of the planform fillet on the subsonic aerodynamic characteristics of configuration BW_TV_2.

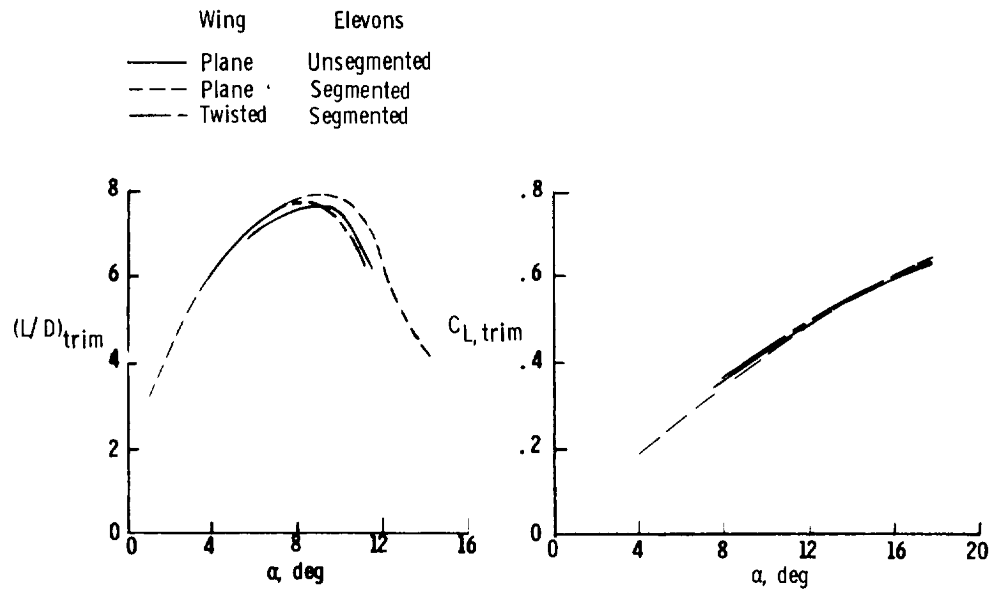


Figure 21.- Some experimental effects of segmented elevons and wing twist on the trimmed subsonic aerodynamic characteristics.

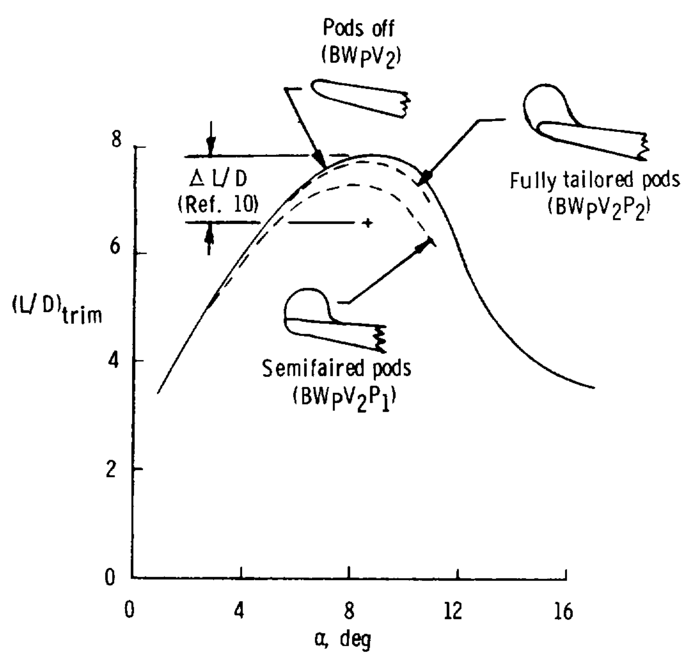


Figure 22.- Experimental subsonic effects of wing-tip-mounted ACPS pods.

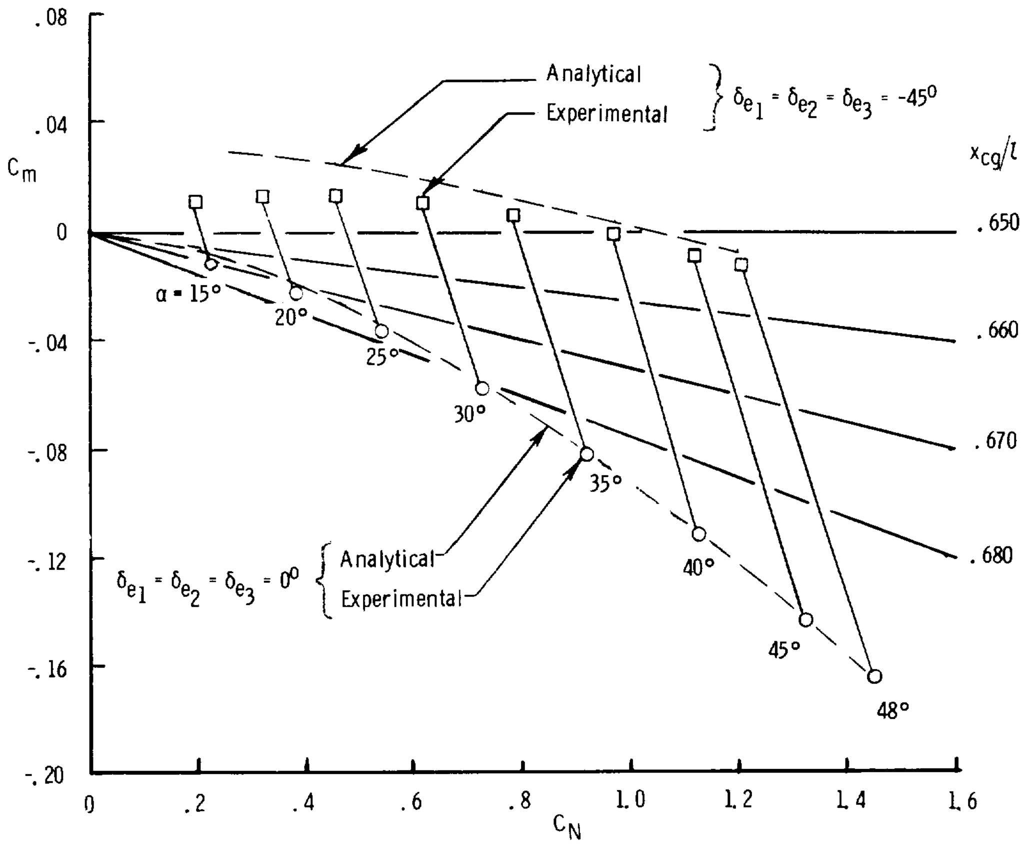


Figure 23.- Experimental hypersonic trim characteristics as compared to analytically obtained values for configuration BW_pV_1.

Effects of segmented elevons and wing twist.- The effect of varying spanwise deflections of trisegmented elevons (more negative for the inboard segments) and wing twist on the longitudinal trim characteristics of the configuration is shown in figure 21. Use of variations in spanwise elevon deflections produced little or no increase in trimmed lift coefficients at landing angles of attack ($\alpha > 15^o$) for the basic plane wing configuration. However, some increase in trimmed $(L/D)_{max}$ was noted for the configuration using variations in spanwise elevon deflection for trim. Only slight changes in trimmed lift coefficients were produced by incorporating linear wing twist (4.5^o washout) in the subsonic model although some reductions in L/D are attributed to the introduction of wing twist for angles of attack near and above $(L/D)_{max}$.

Subsonic ACPS tip pod effects.- Significant degradations in trimmed lift-drag ratios have been associated with the addition of unfaired wing-tip-mounted ACPS pods to space shuttle orbiters (ref. 10). Figure 22 shows the $(L/D)_{max}$ decrement from reference 10

to be about 1.2 which would result in an approach glide-slope angle increase somewhat greater than 1°. An attempt was made to assess the effects of tailoring the ACPS pod external shape on L/D ratios. For this purpose, two wing-tip pod configurations were tested on the plane-wing configuration BW_PV_2 (fig. 5(b)) which fulfilled the volumetric requirements for roll-control ACPS. The two configurations represented semifaired and fully tailored designs. Addition of the semifaired pod to configuration BW_PV_2 produced a trimmed $(L/D)_{max}$ decrement of about 0.7 (fig. 22) whereas the fully tailored fairing of the pods resulted in a decrement of only about 0.1.

Hypersonic analytical and experimental comparisons.- The basic longitudinal aerodynamic characteristics obtained for configuration BW_PV_1 at $M = 10.33$ in the Langley continuous-flow hypersonic tunnel are shown in figure 18. A comparison of these data with the analytically predicted pitch trim characteristics is presented in figure 23. This experimental data comparison indicates a reduction of approximately 5° in maximum trimmed angle-of-attack capability for the configuration with $\delta_{e_1} = \delta_{e_2} = \delta_{e_3} = -45^{\circ}$; this reduction thereby produces an $\alpha_{max,trim}$ of about 40° for the design payload condition ($x_{cg}/l = 0.650$). Experimental effects of fuselage widening and of changing the fuselage nose camber (see ref. 9) indicate the necessity of only minor modifications to increase the trimmed hypersonic maximum angle of attack for the present configuration from 40° to 50°. Although no hypersonic data were obtained for configuration BW_PV_1F (incorporating the planform fillet and the aftward wing movement), estimates of stability and control indicate the possibility of some improvement in hypersonic maximum angle-of-attack trim capability for this configuration.

Summarization of vehicle performance characteristics.- During the course of the present analytical and experimental orbiter wing design study, a configuration BW_TV_2F (incorporating a $0.03\bar{c}$ aft wing movement) was developed which would essentially satisfy the established design guidelines. Figure 24 summarizes the experimental aerodynamic performance, stability, and control characteristics for this configuration. Stable subsonic static margins were found for the configuration throughout the envelope which are in accord with the preset study guidelines as is the $V_{min,des}$ value of 148 knots.

Maximum hypersonic trim capability for configuration BW_PV_1F is estimated at $\alpha_{max,trim} \approx 40^{\circ}$ for the design payload condition. This value is approximately 10° less than the guideline value of 50° which might be attained with some fuselage nose reshaping and/or elevon resizing which would not adversely alter the subsonic flight characteristics.

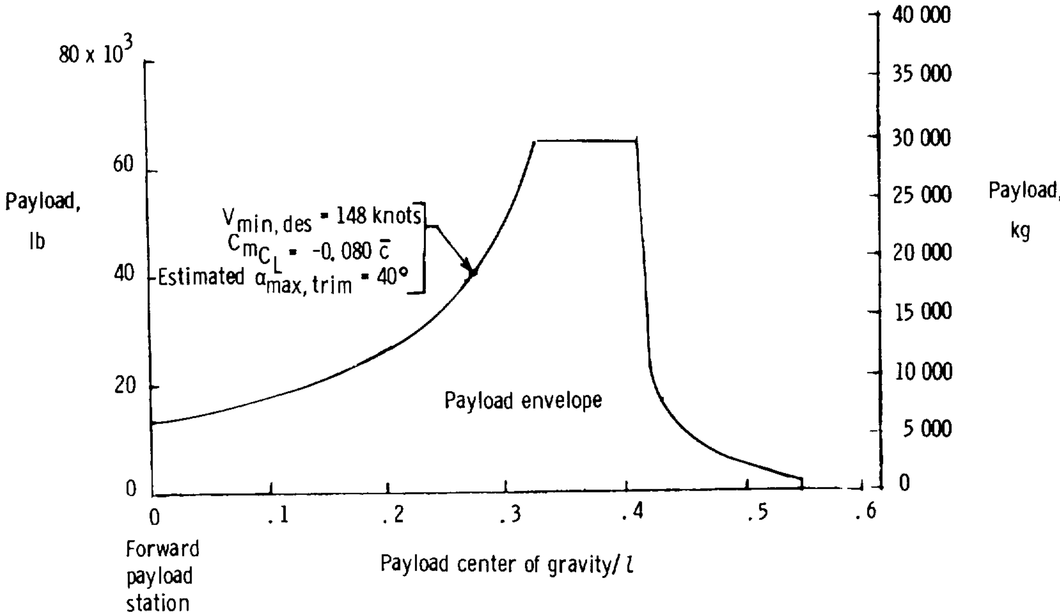


Figure 24.- Summary of experimental performance characteristics for configuration BW_TV_2F as applied to the various landed payload loadings of the space shuttle.

SUMMARY OF RESULTS

An analytical and experimental investigation has been made to define a space shuttle orbiter wing configuration meeting requirements for landing performance, stability, and hypersonic trim for a specified center-of-gravity envelope. The analytical part of the study was facilitated by the use of the Optimal Design Integration system (ODIN). Limited experimental studies were made in the Langley low-turbulence pressure tunnel and the Langley continuous-flow hypersonic tunnel to verify the aerodynamic characteristics of the orbiter configuration selected analytically. Results are summarized as follows:

1. Use of the ODIN system greatly simplified the handling of analytical data while maintaining compliance with the space shuttle general vehicle requirements and allowed the expedient selection of a desirable wing planform. The analytical aerodynamic estimates obtained by using the ODIN system were in reasonable agreement with experimental results obtained subsequently for the orbiter configuration selected.

2. The analytical study suggested reductions in wing sweep to produce a minimum wing area (minimum weight) configuration. Reductions in wing area and sweep also

enhanced the high-angle-of-attack trim capability at hypersonic speeds. This trend, however, was constrained by entry heating considerations to preclude wing leading-edge sweep angles below 45°. Attempting to meet the hypersonic and subsonic guidelines directed the study toward using a negatively swept wing training edge to provide increased hypersonic trim capability and desirable subsonic flight characteristics.

3. The analytically selected orbiter configuration required minor experimental wind-tunnel refinements to provide a viable orbiter configuration. The primary refinement was the addition of a small planform fillet to increase lift coefficients at landing attitudes accompanied by an aft wing movement.

4. Significant reductions in lift-drag ratio losses due to the addition of attitude-control propulsion system wing-tip pods were attained by tailoring the external shape of pods designed to house the roll-attitude control system.

5. The use of sequentially deflected segmented elevons improved subsonic trimmed lift-drag ratios which may be beneficial to landing-approach glide-slope performance.

Langley Research Center,
National Aeronautics and Space Administration,
Hampton, Va., January 18, 1974.

APPENDIX

ANALYTICAL DATA

The characteristics of the wings investigated are presented in this appendix. An index of these characteristics is presented in table V.

TABLE V.- INDEX OF CHARACTERISTICS OF WINGS INVESTIGATED

Wing	x_{wing}/l	S_{ref}, m^2	S_{ref}, ft^2	Λ_{le}, deg	Λ_{te}, deg	A	Subsonic $C_{m_{C_L}}$ (based on $\bar{c}$), P/L out	Subsonic $C_{m_{C_L}}$ (based on $\bar{c}$), 40K P/L	$V_{min,des}$, knots (40K P/L)	Hypersonic $\alpha_{max,trim}$, deg (40K P/L)	XSF	YSF	$\frac{S_{elevon}}{S_{ref}}$	Page
W_1	0.5404	207.0	2228	60.0	0.0	1.74	-0.0282	-0.0843	204	59	0.8	0.8	0.131	47
W_2	.4928	258.7	2785	65.2		1.39	-.0282	-.0759	203	45	1.0	.8	.131	48
W_3	.4517	310.5	3342	68.9		1.16	-.0293	-.0721	204	36	1.2	.8	.131	49
W_4	.4152	362.2	3899	71.7		.99	-.0310	-.0708	206	31	1.4	.8	.131	50
W_5	.3805	414.0	4456	73.9		.87	-.0316	-.0696	207	29	1.6	.8	.131	51
W_6	.5192	234.5	2524	54.2		2.14	-.0290	-.0870	179	53	.8	1.0	.144	52
W_7	.4718	293.2	3156	60.0		1.71	-.0275	-.0770	177	41	1.0	1.0	.144	53
W_8	.4335	351.8	3787	64.3		1.42	-.0318	-.0764	178	33	1.2	1.0	.144	54
W_9	.3942	410.4	4418	67.6		1.22	-.0312	-.0727	178	30	1.4	1.0	.144	55
W_{10}	.3586	469.1	5049	70.2		1.07	-.0317	-.0712	178	28	1.6	1.0	.144	56
W_{11}	.5074	262.9	2830	49.1		2.54	-.0278	-.0873	161	48	.8	1.2	.155	57
W_{12}	.4627	328.6	3537	55.3		2.03	-.0288	-.0798	158	37	1.0	1.2	.155	58
W_{13}	.4243	394.3	4244	60.0		1.69	-.0324	-.0786	158	31	1.2	1.2	.155	59
W_{14}	.3842	460.0	4952	63.7		1.45	-.0312	-.0741	157	28	1.4	1.2	.155	60
W_{15}	.3486	525.7	5659	66.6		1.27	-.0316	-.0725	157	27	1.6	1.2	.155	61
W_{16}	.5010	291.6	3139	44.7		2.94	-.0283	-.0891	147	44	.8	1.4	.163	62
W_{17}	.4563	364.6	3924	51.1		2.35	-.0277	-.0800	143	34	1.0	1.4	.163	63
W_{18}	.4179	437.5	4709	56.0		1.96	-.0306	-.0779	142	30	1.2	1.4	.163	64
W_{19}	.3796	510.4	5494	60.0		1.68	-.0311	-.0752	141	27	1.4	1.4	.163	65
W_{20}	.3431	583.3	6279	63.2		1.47	-.0314	-.0735	141	26	1.6	1.4	.163	66
W_{21}	.4973	320.7	3452	40.9		3.34	-.0287	-.0906	136	40	.8	1.6	.169	67
W_{22}	.4554	400.9	4315	47.3		2.67	-.0287	-.0821	132	32	1.0	1.6	.169	68
W_{23}	.4179	481.0	5178	52.4		2.23	-.0324	-.0810	131	28	1.2	1.6	.169	69
W_{24}	.3778	561.2	6041	56.6		1.91	-.0310	-.0762	129	27	1.4	1.6	.169	70
W_{25}	.3422	641.4	6904	60.0		1.67	-.0312	-.0745	129	26	1.6	1.6	.169	71
W_{26}	.4882	279.7	3011	54.8		2.08	-.0278	-.0817	168	44	.9	1.1	.150	72
W_{27}	.4791	311.9	3357	50.2		2.44	-.0254	-.0806	151	40	.9	1.3	.159	73
W_{28}	.4763	344.4	3707	46.1		2.79	-.0272	-.0837	139	37	.9	1.5	.166	74
W_{29}	.4417	381.2	4103	55.7		1.99	-.0327	-.0818	150	32	1.1	1.3	.159	75
W_{30}	.4572	346.5	3730	53.1		2.19	-.0261	-.0776	150	36	1.0	1.3	.159	76
W_{31}	.4846	295.7	3183	52.4		2.26	-.0289	-.0836	159	42	.9	1.2	.155	77
W_{32}	.4773	328.0	3531	48.1		2.62	-.0261	-.0819	144	38	.9	1.4	.163	78
W_{33}	.5046	277.1	2983	46.8		2.74	-.0297	-.0900	154	46	.8	1.3	.159	79
W_{34}	.5366	233.1	2509	47.8		2.87	-.0286	-.0940	171	59	.7	1.1	.150	80
W_{35}	.5320	214.7	2311	45.3		2.71	-.0289	-.0949	163	57	.7	1.2	.155	81
W_{27} (Mod)	.4773	328.4	3535	50.2	-7.0	2.31	-.0281	-.0804	150	41	.9	1.3	.183	82
W_{33} (Mod)	.4955	314.7	3387	46.8	-11.0	2.42	-.0280	-.0804	150	49	.8	1.3	.216	83

ODIN Wing W_1

1. OVERALL CONFIGURATION		
AREA, PLANFORM (SFT)		2999.4
LENGTH, NOSE TO WING LE AT BODY		710.02 IN
LENGTH, NOSE TO WING C/4		903.27 IN
ANGLE, GROUND PLANE	*FIXED*	17.00 DEG
2. FUSELAGE		
AREA, WETTED	*FIXED*	6307.0 SFT
LENGTH, NOSE TO END OF BODY	*FIXED*	1315.0 IN
3. WING		
AREA, THEORETICAL OR TOTAL		2228.1 SFT
AREA, ELEVON		291.53 SFT
SPAN		746.40 IN
CHORD, MEAN AERODYNAMIC		510.88 IN
CHORD, CENTERLINE ROOT		753.05 IN
CHORD, TIP		106.66 IN
TAPER RATIO, THEORETICAL		.14163
ASPECT RATIO, THEORETICAL		1.7364
ASPECT RATIO, EXPOSED SPAN		1.5882
ANGLE, LEADING EDGE SWEEP		59.998 DEG
ANGLE, TRAILING EDGE SWEEP	*FIXED*	0.0 DEG
ANGLE, DIHEDRAL	*FIXED*	7.0 DEG
ANGLE, INCIDENCE	*FIXED*	1.5 DEG
AIRFOIL SECTION, ROOT	*FIXED*	008-64
AIRFOIL SECTION, TIP	*FIXED*	008-64

4. 040A MASS PROPERTIES

FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC L)
ORBITER LNDG (W/40K PL)	191590.2	70.881	64.684
ORBITER LNDG (W/O PL)	151590.2	73.268	66.863
WING WEIGHT	12493.5		
TPS WEIGHT	22990.7		

5. PRINCIPAL PARAMETERS	
X-SCALE FACTOR	SCLX= .80000
Y-SCALE FACTOR	SCLY= .80000
DISTANCE TO LEADING EDGE OF EXPOSED WING	XOF=710.023 IN
6. LANDING PERFORMANCE	
MINIMUM LANDING SPEED (W/40K PL)	203.5 KT
STATIC MARGIN (SUBSONIC) (W/40K PL)	-.0843
STATIC MARGIN (SUBSONIC) (W/O PL)	-.0282
TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)	.6134
7. HYPERSONIC AERODYNAMIC TRIM DATA	
TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG	58.59 DEG

ODIN Wing W_2

```
1. OVERALL CONFIGURATION
      AREA, PLANFORM (SFT)                                          3321.0
      LENGTH, NOSE TO WING LE AT BODY                               648.44 IN
      LENGTH, NOSE TO WING C/4                                      890.00 IN
      ANGLE, GROUND PLANE                                *FIXED*    17.00 DEG

2. FUSELAGE
      AREA, WETTED                                       *FIXED*    6307.0 SFT
      LENGTH, NOSE TO END OF BODY                        *FIXED*    1315.0 IN

3. WING
      AREA, THEORETICAL OR TOTAL                                    2785.1 SFT
      AREA, ELEVON                                                  364.42 SFT
      SPAN                                                          746.40 IN
      CHORD, MEAN AERODYNAMIC                                       638.60 IN
      CHORD, CENTERLINE ROOT                                        941.31 IN
      CHORD, TIP                                                    133.32 IN
      TAPER RATIO, THEORETICAL                                      .14163
      ASPECT RATIO, THEORETICAL                                     1.3891
      ASPECT RATIO, EXPOSED SPAN                                    1.2705
      ANGLE, LEADING EDGE SWEEP                                     65.207 DEG
      ANGLE, TRAILING EDGE SWEEP                         *FIXED*       0.0 DEG
      ANGLE, DIHEDRAL                                    *FIXED*       7.0 DEG
      ANGLE, INCIDENCE                                   *FIXED*       1.5 DEG
      AIRFOIL SECTION, ROOT                              *FIXED*    008-64
      AIRFOIL SECTION, TIP                               *FIXED*    008-64

4. 040A MASS PROPERTIES
      FLIGHT CONDITION            WEIGHT (LB)     X-CG (FT)        X-CG (PC L)
      ORBITER LNDG (W/40K PL)     194150.0        71.624           65.362
      ORBITER LNDG (W/O PL)       154150.0        74.165           67.681
      WING WEIGHT                 12994.4
      TPS WEIGHT                  25049.5

5. PRINCIPAL PARAMETERS
      X-SCALE FACTOR                                         SCLX= 1.0000
      Y-SCALE FACTOR                                         SCLY= .80000
      DISTANCE TO LEADING EDGE OF EXPOSED WING                XOF=648.442 IN

6. LANDING PERFORMANCE
      MINIMUM LANDING SPEED (W/40K PL)                            203.3 KT
      STATIC MARGIN (SUBSONIC)    (W/40K PL)                      -.0759
      STATIC MARGIN (SUBSONIC)    (W/O PL)                        -.0282
      TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)                   .4980

7. HYPERSONIC AERODYNAMIC TRIM DATA
      TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG                      45.35  DEG
```

ODIN Wing W_3

1. OVERALL CONFIGURATION

AREA, PLANFORM (SFT)		3642.6
LENGTH, NOSE TO WING LE AT BODY		594.36 IN
LENGTH, NOSE TO WING C/4		884.23 IN
ANGLE, GROUND PLANE	*FIXED*	17.00 DEG

2. FUSELAGE

AREA, WETTED	*FIXED*	6307.0 SFT
LENGTH, NOSE TO END OF BODY	*FIXED*	1315.0 IN

3. WING

AREA, THEORETICAL OR TOTAL		3342.1 SFT
AREA, ELEVON		437.30 SFT
SPAN		746.40 IN
CHORD, MEAN AERODYNAMIC		766.32 IN
CHORD, CENTERLINE ROOT		1129.6 IN
CHORD, TIP		159.98 IN
TAPER RATIO, THEORETICAL		.14163
ASPECT RATIO, THEORETICAL		1.1576
ASPECT RATIO, EXPOSED SPAN		1.0588
ANGLE, LEADING EDGE SWEEP		68.947 DEG
ANGLE, TRAILING EDGE SWEEP	*FIXED*	0.0 DEG
ANGLE, DIHEDRAL	*FIXED*	7.0 DEG
ANGLE, INCIDENCE	*FIXED*	1.5 DEG
AIRFOIL SECTION, ROOT	*FIXED*	008-64
AIRFOIL SECTION, TIP	*FIXED*	008-64

4. 040A MASS PROPERTIES

FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC L)
ORBITER LNDG (W/40K PL)	196729.0	72.551	66.208
ORBITER LNDG (W/O PL)	156729.0	75.286	68.704
WING WEIGHT	13508.6		
TPS WEIGHT	27114.4		

5. PRINCIPAL PARAMETERS

X-SCALE FACTOR	SCLX= 1.2000
Y-SCALE FACTOR	SCLY= .80000
DISTANCE TO LEADING EDGE OF EXPOSED WING	XOF=594.360 IN

6. LANDING PERFORMANCE

MINIMUM LANDING SPEED (W/40K PL)	204.1 KT
STATIC MARGIN (SUBSONIC) (W/40K PL)	-.0721
STATIC MARGIN (SUBSONIC) (W/O PL)	-.0293
TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)	.4172

7. HYPERSONIC AERODYNAMIC TRIM DATA

TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG	36.33 DEG

ODIN Wing W_4

```
1. OVERALL CONFIGURATION
      AREA, PLANFORM (SFT)                                           3964.2
      LENGTH, NOSE TO WING LE AT BODY                                546.17 IN
      LENGTH, NOSE TO WING C/4                                       884.35 IN
      ANGLE, GROUND PLANE                                 *FIXED*    17.00 DEG

2. FUSELAGE
      AREA, WETTED                                        *FIXED*    6307.0 SFT
      LENGTH, NOSE TO END OF BODY                         *FIXED*    1315.0 IN

3. WING
      AREA, THEORETICAL OR TOTAL                                     3899.1 SFT
      AREA, ELEVON                                                   510.18 SFT
      SPAN                                                           746.40 IN
      CHORD, MEAN AERODYNAMIC                                        894.04 IN
      CHORD, CENTERLINE ROOT                                         1317.8 IN
      CHORD, TIP                                                     186.65 IN
      TAPER RATIO, THEORETICAL                                       .14163
      ASPECT RATIO, THEORETICAL                                      .99223
      ASPECT RATIO, EXPOSED SPAN                                     .90753
      ANGLE, LEADING EDGE SWEEP                                      71.740 DEG
      ANGLE, TRAILING EDGE SWEEP                          *FIXED*       0.0 DEG
      ANGLE, DIHEDRAL                                     *FIXED*       7.0 DEG
      ANGLE, INCIDENCE                                    *FIXED*       1.5 DEG
      AIRFOIL SECTION, ROOT                               *FIXED*    008-64
      AIRFOIL SECTION, TIP                                *FIXED*    008-64

4. 040A MASS PROPERTIES
      FLIGHT CONDITION          WEIGHT (LB)     X-CG (FT)        X-CG (PC L)
      ORBITER LNDG (W/40K PL)   199310.4        73.656           67.217
      ORBITER LNDG (W/O PL)     159310.4        76.625           69.926
      WING WEIGHT               14021.4
      TPS WEIGHT                29183.0

5. PRINCIPAL PARAMETERS
      X-SCALE FACTOR                                        SCLX= 1.4000
      Y-SCALE FACTOR                                        SCLY= .80000
      DISTANCE TO LEADING EDGE OF EXPOSED WING               XOF=546.165 IN

6. LANDING PERFORMANCE
      MINIMUM LANDING SPEED (W/40K PL)                               205.6 KT
      STATIC MARGIN (SUBSONIC)    (W/40K PL)                         -.0708
      STATIC MARGIN (SUBSONIC)    (W/O PL)                           -.0310
      TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)                      .3572

7. HYPERSONIC AERODYNAMIC TRIM DATA
      TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG                         31.46  DEG
```

ODIN Wing W_5

1. OVERALL CONFIGURATION		
AREA, PLANFORM (SFT)		4285.8
LENGTH, NOSE TO WING LE AT BODY		500.27 IN
LENGTH, NOSE TO WING C/4		886.77 IN
ANGLE, GROUND PLANE	*FIXED*	17.00 DEG
2. FUSELAGE		
AREA, WETTED	*FIXED*	6307.0 SFT
LENGTH, NOSE TO END OF BODY	*FIXED*	1315.0 IN
3. WING		
AREA, THEORETICAL OF TOTAL		4456.2 SFT
AREA, ELEVON		583.07 SFT
SPAN		746.40 IN
CHORD, MEAN AERODYNAMIC		1021.8 IN
CHORD, CENTERLINE ROOT		1506.1 IN
CHORD, TIP		213.31 IN
TAPER RATIO, THEORETICAL		.14163
ASPECT RATIO, THEORETICAL		.86820
ASPECT RATIO, EXPOSED SPAN		.79409
ANGLE, LEADING EDGE SWEEP		73.896 DEG
ANGLE, TRAILING EDGE SWEEP	*FIXED*	0.0 DEG
ANGLE, DIHEDRAL	*FIXED*	7.0 DEG
ANGLE, INCIDENCE	*FIXED*	1.5 DEG
AIRFOIL SECTION, ROOT	*FIXED*	008-64
AIRFOIL SECTION, TIP	*FIXED*	008-64

4. 040A MASS PROPERTIES

FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC L)
ORBITER LNDG (W/40K PL)	201884.8	74.906	68.358
ORBITER LNDG (W/O PL)	161884.8	78.136	71.305
WING WEIGHT	14524.8		
TPS WEIGHT	31254.1		

5. PRINCIPAL PARAMETERS	
X-SCALE FACTOR	SCLX= 1.6000
Y-SCALE FACTOR	SCLY= .80000
DISTANCE TO LEADING EDGE OF EXPOSED WING	XOF=500.272 IN
6. LANDING PERFORMANCE	
MINIMUM LANDING SPEED (W/40K PL)	206.9 KT
STATIC MARGIN (SUBSONIC) (W/40K PL)	-.0696
STATIC MARGIN (SUBSONIC) (W/O PL)	-.0316
TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)	.3125
7. HYPERSONIC AERODYNAMIC TRIM DATA	
TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG	28.85 DEG

ODIN Wing W_6

```
1. OVERALL CONFIGURATION
     AREA, PLANFORM (SFT)                                             3321.0
     LENGTH, NOSE TO WING LE AT BODY                                  682.59 IN
     LENGTH, NOSE TO WING C/4                                         893.22 IN
     ANGLE, GROUND PLANE                                   *FIXED*    17.00 DEG

2. FUSELAGE
     AREA, WETTED                                          *FIXED*    6307.0 SFT
     LENGTH, NOSE TO END OF BODY                           *FIXED*    1315.0 IN

3. WING
     AREA, THEORETICAL OR TOTAL                                       2524.7 SFT
     AREA, ELEVON                                                     364.42 SFT
     SPAN                                                             882.00 IN
     CHORD, MEAN AERODYNAMIC                                          487.70 IN
     CHORD, CENTERLINE ROOT                                           717.72 IN
     CHORD, TIP                                                       106.66 IN
     TAPER RATIO, THEORETICAL                                         .14860
     ASPECT RATIO, THEORETICAL                                        2.1398
     ASPECT RATIO, EXPOSED SPAN                                       1.9852
     ANGLE, LEADING EDGE SWEEP                                        54.181 DEG
     ANGLE, TRAILING EDGE SWEEP                            *FIXED*       0.0 DEG
     ANGLE, DIHEDRAL                                       *FIXED*       7.0 DEG
     ANGLE, INCIDENCE                                      *FIXED*       1.5 DEG
     AIRFOIL SECTION, ROOT                                 *FIXED*    008-64
     AIRFOIL SECTION, TIP                                  *FIXED*    008-64

4. 040A MASS PROPERTIES
     FLIGHT CONDITION            WEIGHT (LB)     X-CG (FT)        X-CG (PC L)
     ORBITER LNDG (W/40K PL)     194958.8        70.967           64.763
     ORBITER LNDG (W/O PL)       154958.8        73.325           66.915
     WING WEIGHT                 14260.4
     TPS WEIGHT                  24592.4

5. PRINCIPAL PARAMETERS
     X-SCALE FACTOR                                          SCLX= .80000
     Y-SCALE FACTOR                                          SCLY= 1.0000
     DISTANCE TO LEADING EDGE OF EXPOSED WING                 XOF=682.590 IN

6. LANDING PERFORMANCE
     MINIMUM LANDING SPEED (W/40K PL)                               179.1 KT
     STATIC MARGIN (SUBSONIC)    (W/40K PL)                         -.0870
     STATIC MARGIN (SUBSONIC)    (W/O PL)                           -.0290
     TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)                      .7111

7. HYPERSONIC AERODYNAMIC TRIM DATA
     TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG                         53.21  DEG
```

ODIN Wing W_7

1. OVERALL CONFIGURATION

AREA, PLANFORM (SFT)		3723.0
LENGTH, NOSE TO WING LE AT BODY		620.68 IN
LENGTH, NOSE TO WING C/4		883.97 IN
ANGLE, GROUND PLANE	*FIXED*	17.00 DEG

2. FUSELAGE

AREA, WETTED	*FIXED*	6307.0 SFT
LENGTH, NOSE TO END OF BODY	*FIXED*	1315.0 IN

3. WING

AREA, THEORETICAL OR TOTAL		3155.8 SFT
AREA, ELEVON		455.52 SFT
SPAN		882.00 IN
CHORD, MEAN AERODYNAMIC		609.63 IN
CHORD, CENTERLINE ROOT		897.14 IN
CHORD, TIP		133.32 IN
TAPER RATIO, THEORETICAL		.14860
ASPECT RATIO, THEORETICAL		1.7118
ASPECT RATIO, EXPOSED SPAN		1.5882
ANGLE, LEADING EDGE SWEEP		59.998 DEG
ANGLE, TRAILING EDGE SWEEP	*FIXED*	0.0 DEG
ANGLE, DIHEDRAL	*FIXED*	7.0 DEG
ANGLE, INCIDENCE	*FIXED*	1.5 DEG
AIRFOIL SECTION, ROOT	*FIXED*	008-64
AIRFOIL SECTION, TIP	*FIXED*	008-64

4. 040A MASS PROPERTIES

FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC L)
ORBITER LNDG (W/40K PL)	197850.1	71.748	65.475
ORBITER LNDG (W/O PL)	157850.1	74.260	67.768
WING WEIGHT	14703.5		
TPS WEIGHT	27040.6		

5. PRINCIPAL PARAMETERS

X-SCALE FACTOR	SCLX= 1.0000
Y-SCALE FACTOR	SCLY= 1.0000
DISTANCE TO LEADING EDGE OF EXPOSED WING	XOF=620.678 IN

6. LANDING PERFORMANCE

MINIMUM LANDING SPEED (W/40K PL)	176.9 KT
STATIC MARGIN (SUBSONIC) (W/40K PL)	-.0770
STATIC MARGIN (SUBSONIC) (W/O PL)	-.0275
TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)	.5917

7. HYPERSONIC AERODYNAMIC TRIM DATA

TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG	40.83 DEG

ODIN Wing W_8

```
1. OVERALL CONFIGURATION
      AREA, PLANFORM (SFT)                                              4125.0
      LENGTH, NOSE TO WING LE AT BODY                                   570.47 IN
      LENGTH, NOSE TO WING C/4                                          886.42 IN
      ANGLE, GROUND PLANE                                   *FIXED*     17.00 DEG

2. FUSELAGE
      AREA, WETTED                                          *FIXED*     6307.0 SFT
      LENGTH, NOSE TO END OF BODY                           *FIXED*     1315.0 IN

3. WING
      AREA, THEORETICAL OR TOTAL                                        3787.0 SFT
      AREA, ELEVON                                                      546.63 SFT
      SPAN                                                              882.00 IN
      CHORD, MEAN AERODYNAMIC                                           731.55 IN
      CHORD, CENTERLINE ROOT                                            1076.6 IN
      CHORD, TIP                                                        159.98 IN
      TAPER RATIO, THEORETICAL                                          .14860
      ASPECT RATIO, THEORETICAL                                         1.4265
      ASPECT RATIO, EXPOSED SPAN                                        1.3235
      ANGLE, LEADING EDGE SWEEP                                         64.305 DEG
      ANGLE, TRAILING EDGE SWEEP                            *FIXED*        0.0 DEG
      ANGLE, DIHEDRAL                                       *FIXED*        7.0 DEG
      ANGLE, INCIDENCE                                      *FIXED*        1.5 DEG
      AIRFOIL SECTION, ROOT                                 *FIXED*     008-64
      AIRFOIL SECTION, TIP                                  *FIXED*     008-64

4. 040A MASS PROPERTIES
      FLIGHT CONDITION              WEIGHT (LB)     X-CG (FT)        X-CG (PC L)
      ORBITER LNDG (W/40K PL)       200777.2        72.776           66.413
      ORBITER LNDG (W/0 PL)         160777.2        75.498           68.898
      WING WEIGHT                   15175.0
      TPS WEIGHT                    29456.2

5. PRINCIPAL PARAMETERS
      X-SCALE FACTOR                                          SCLX= 1.2000
      Y-SCALE FACTOR                                          SCLY= 1.0000
      DISTANCE TO LEADING EDGE OF EXPOSED WING                 XOF=570.473 IN

6. LANDING PERFORMANCE
      MINIMUM LANDING SPEED (W/40K PL)                                 177.5 KT
      STATIC MARGIN (SUBSONIC)      (W/40K PL)                         -.0764
      STATIC MARGIN (SUBSONIC)      (W/0 PL)                           -.0318
      TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)                        .4969

7. HYPERSONIC AERODYNAMIC TRIM DATA
      TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG                           32.97  DEG
```

ODIN Wing W_9

1. OVERALL CONFIGURATION

AREA, PLANFORM (SFT)		4527.0
LENGTH, NOSE TO WING LE AT BODY		518.90 IN
LENGTH, NOSE TO WING C/4		887.50 IN
ANGLE, GROUND PLANE	*FIXED*	17.00 DEG

2. FUSELAGE

AREA, WETTED	*FIXED*	6307.0 SFT
LENGTH, NOSE TO END OF BODY	*FIXED*	1315.0 IN

3. WING

AREA, THEORETICAL OR TOTAL		4418.1 SFT
AREA, ELEVON		637.73 SFT
SPAN		882.00 IN
CHORD, MEAN AERODYNAMIC		853.48 IN
CHORD, CENTERLINE ROOT		1256.0 IN
CHORD, TIP		186.65 IN
TAPER RATIO, THEORETICAL		.14860
ASPECT RATIO, THEORETICAL		1.2227
ASPECT RATIO, EXPOSED SPAN		1.1344
ANGLE, LEADING EDGE SWEEP		67.588 DEG
ANGLE, TRAILING EDGE SWEEP	*FIXED*	0.0 DEG
ANGLE, DIHEDRAL	*FIXED*	7.0 DEG
ANGLE, INCIDENCE	*FIXED*	1.5 DEG
AIRFOIL SECTION, ROOT	*FIXED*	008-64
AIRFOIL SECTION, TIP	*FIXED*	008-64

4. 040A MASS PROPERTIES

FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC L)
ORBITER LNDG (W/40K PL)	203721.8	73.913	67.451
ORBITER LNDG (W/0 PL)	163721.8	76.864	70.144
WING WEIGHT	15659.4		
TPS WEIGHT	31956.4		

5. PRINCIPAL PARAMETERS

X-SCALE FACTOR	SCLX= 1.4000
Y-SCALE FACTOR	SCLY= 1.0000
DISTANCE TO LEADING EDGE OF EXPOSED WING	XCF=518.903 IN

6. LANDING PERFORMANCE

MINIMUM LANDING SPEED (W/40K PL)	177.5 KT
STATIC MARGIN (SUBSONIC) (W/40K PL)	-.0727
STATIC MARGIN (SUBSONIC) (W/0 PL)	-.0312
TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)	.4323

7. HYPERSONIC AERODYNAMIC TRIM DATA

TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG	29.60 DEG

ODIN Wing W_{10}

```
1. OVERALL CONFIGURATION
      AREA, PLANFORM (SFT)                                             4929.0
      LENGTH, NOSE TO WING LE AT BODY                                  472.06 IN
      LENGTH, NOSE TO WING C/4                                         893.31 IN
      ANGLE, GROUND PLANE                                    *FIXED*   17.00 DEG

2. FUSELAGE
      AREA, WETTED                                           *FIXED*   6307.0 SFT
      LENGTH, NOSE TO END OF BODY                            *FIXED*   1315.0 IN

3. WING
      AREA, THEORETICAL OR TOTAL                                       5049.3 SFT
      AREA, ELEVON                                                     728.84 SFT
      SPAN                                                             882.00 IN
      CHORD, MEAN AERODYNAMIC                                          975.40 IN
      CHORD, CENTERLINE ROOT                                           1435.4 IN
      CHORD, TIP                                                       213.31 IN
      TAPER RATIO, THEORETICAL                                         .14860
      ASPECT RATIO, THEORETICAL                                        1.0699
      ASPECT RATIO, EXPOSED SPAN                                       .99261
      ANGLE, LEADING EDGE SWEEP                                        70.157 DEG
      ANGLE, TRAILING EDGE SWEEP                             *FIXED*      0.0 DEG
      ANGLE, DIHEDRAL                                        *FIXED*      7.0 DEG
      ANGLE, INCIDENCE                                       *FIXED*      1.5 DEG
      AIRFOIL SECTION, ROOT                                  *FIXED*   008-64
      AIRFOIL SECTION, TIP                                   *FIXED*   008-64

4. 040A MASS PROPERTIES
      FLIGHT CONDITION               WEIGHT (LB)     X-CG (FT)        X-CG (PCT)
      ORBITER LNDG (W/40K PL)        206672.3        75.231           68.654
      ORBITER LNDG (W/O PL)          166672.3        78.446           71.588
      WING WEIGHT                    16146.7
      TPS WEIGHT                     34419.6

5. PRINCIPAL PARAMETERS
      X-SCALE FACTOR                                          SCLX= 1.6000
      Y-SCALE FACTOR                                          SCLY= 1.0000
      DISTANCE TO LEADING EDGE OF EXPOSED WING                 XOF=472.056 IN

6. LANDING PERFORMANCE
      MINIMUM LANDING SPEED (W/40K PL)                                 178.2 KT
      STATIC MARGIN (SUBSONIC)    (W/40K PL)                           -.0712
      STATIC MARGIN (SUBSONIC)    (W/O PL)                             -.0317
      TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)                        .3808

7. HYPERSONIC AERODYNAMIC TRIM DATA
      TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG                           27.57  DEG
```

ODIN Wing W_{11}

1. OVERALL CONFIGURATION

AREA, PLANFORM (SFT)		3642.6
LENGTH, NOSE TO WING LE AT BODY		667.15 IN
LENGTH, NOSE TO WING C/4		889.36 IN
ANGLE, GROUND PLANE	*FIXED*	17.00 DEG

2. FUSELAGE

AREA, WETTED	*FIXED*	6307.0 SFT
LENGTH, NOSE TO END OF BODY	*FIXED*	1315.0 IN

3. WING

AREA, THEORETICAL OR TOTAL		2829.6 SFT
AREA, ELEVON		437.30 SFT
SPAN		1017.6 IN
CHORD, MEAN AERODYNAMIC		472.27 IN
CHORD, CENTERLINE ROOT		694.16 IN
CHORD, TIP		106.66 IN
TAPER RATIO, THEORETICAL		.15365
ASPECT RATIO, THEORETICAL		2.5414
ASPECT RATIO, EXPOSED SPAN		2.3823
ANGLE, LEADING EDGE SWEEP		49.105 DEG
ANGLE, TRAILING EDGE SWEEP	*FIXED*	0.0 DEG
ANGLE, DIHEDRAL	*FIXED*	7.0 DEG
ANGLE, INCIDENCE	*FIXED*	1.5 DEG
AIRFOIL SECTION, ROOT	*FIXED*	008-64
AIRFOIL SECTION, TIP	*FIXED*	008-64

4. 040A MASS PROPERTIES

FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC L)
ORBITER LNDG (W/40K PL)	198306.2	71.103	64.887
ORBITER LNDG (W/O PL)	158306.2	73.446	67.025
WING WEIGHT	15588.4		
TPS WEIGHT	20211.9		

5. PRINCIPAL PARAMETERS

X-SCALE FACTOR	SCLX= .80000
Y-SCALE FACTOR	SCLY= 1.2000
DISTANCE TO LEADING EDGE OF EXPOSED WING	XOF=667.154 IN

6. LANDING PERFORMANCE

MINIMUM LANDING SPEED (W/40K PL)	160.7 KT
STATIC MARGIN (SUBSONIC) (W/40K PL)	-.0873
STATIC MARGIN (SUBSONIC) (W/O PL)	-.0278
TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)	.8017

7. HYPERSONIC AERODYNAMIC TRIM DATA

TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG	48.43 DEG

ODIN Wing W_{12}

```
1. OVERALL CONFIGURATION
      AREA, PLANFORM (SFT)                                              4125.0
      LENGTH, NOSE TO WING LE AT BODY                                   608.36 IN
      LENGTH, NOSE TO WING C/4                                          886.12 IN
      ANGLE, GROUND PLANE                                   *FIXED*     17.00 DEG

2. FUSELAGE
      AREA, WETTED                                          *FIXED*     6307.0 SFT
      LENGTH, NOSE TO END OF BODY                           *FIXED*     1315.0 IN

3. WING
      AREA, THEORETICAL OR TOTAL                                        3537.0 SFT
      AREA, ELEVON                                                      546.63 SFT
      SPAN                                                              1017.6 IN
      CHORD, MEAN AERODYNAMIC                                           590.33 IN
      CHORD, CENTERLINE ROOT                                            867.70 IN
      CHORD, TIP                                                        133.32 IN
      TAPER RATIO, THEORETICAL                                          .15365
      ASPECT RATIO, THEORETICAL                                         2.0331
      ASPECT RATIO, EXPOSED SPAN                                        1.9058
      ANGLE, LEADING EDGE SWEEP                                         55.283 DEG
      ANGLE, TRAILING EDGE SWEEP                            *FIXED*        0.0 DEG
      ANGLE, DIHEDRAL                                       *FIXED*        7.0 DEG
      ANGLE, INCIDENCE                                      *FIXED*        1.5 DEG
      AIRFOIL SECTION, ROOT                                 *FIXED*     008-64
      AIRFOIL SECTION, TIP                                  *FIXED*     008-64

4. 040A MASS PROPERTIES
      FLIGHT CONDITION              WEIGHT (LB)      X-CG (FT)          X-CG (PC L)
      ORBITER LNDG (W/40K PL)       201537.7         71.967             65.675
      ORBITER LNDG (W/O PL)         161537.7         74.476             67.965
      WING WEIGHT                   16378.3
      TPS WEIGHT                    29053.4

5. PRINCIPAL PARAMETERS
      X-SCALE FACTOR                                                SCLX= 1.0000
      Y-SCALE FACTOR                                                SCLY= 1.2000
      DISTANCE TO LEADING EDGE OF EXPOSED WING                      XOF=608.363 IN

6. LANDING PERFORMANCE
      MINIMUM LANDING SPEED (W/40K PL)                                  158.0 KT
      STATIC MARGIN (SUBSONIC)    (W/40K PL)                            -.0798
      STATIC MARGIN (SUBSONIC)    (W/O PL)                              -.0288
      TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)                         .6738

7. HYPERSONIC AERODYNAMIC TRIM DATA
      TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG                            36.79  DEG
```

ODIN Wing W_{13}

```
1. OVERALL CONFIGURATION
      AREA, PLANFORM (SFT)                                      4607.4
      LENGTH, NOSE TO WING LE AT BODY                           557.64 IN
      LENGTH, NOSE TO WING C/4                                  890.95 IN
      ANGLE, GROUND PLANE                            *FIXED*    17.00 DEG

2. FUSELAGE
      AREA, WETTED                                   *FIXED*    6307.0 SFT
      LENGTH, NOSE TO END OF BODY                    *FIXED*    1315.0 IN

3. WING
      AREA, THEORETICAL OR TOTAL                                4244.4 SFT
      AREA, ELEVON                                              655.95 SFT
      SPAN                                                      1017.6 IN
      CHORD, MEAN AERODYNAMIC                                   708.40 IN
      CHORD, CENTERLINE ROOT                                    1041.2 IN
      CHORD, TIP                                                159.98 IN
      TAPER RATIO, THEORETICAL                                  .15365
      ASPECT RATIO, THEORETICAL                                 1.6943
      ASPECT RATIO, EXPOSED SPAN                                1.5882
      ANGLE, LEADING EDGE SWEEP                                 59.998 DEG
      ANGLE, TRAILING EDGE SWEEP                     *FIXED*       0.0 DEG
      ANGLE, DIHEDRAL                                *FIXED*       7.0 DEG
      ANGLE, INCIDENCE                               *FIXED*       1.5 DEG
      AIRFOIL SECTION, ROOT                          *FIXED*    008-64
      AIRFOIL SECTION, TIP                           *FIXED*    008-64

4. 040A MASS PROPERTIES
      FLIGHT CONDITION           WEIGHT (LB)     X-CG (FT)      X-CG (PC L)
      ORBITER LNDG (W/40K PL)    204814.6        73.055         66.668
      ORBITER LNDG (W/O PL)      164814.6        75.779         69.154
      WING WEIGHT                16804.9
      TPS WEIGHT                 31903.7

5. PRINCIPAL PARAMETERS
      X-SCALE FACTOR                                      SCLX= 1.2000
      Y-SCALE FACTOR                                      SCLY= 1.2000
      DISTANCE TO LEADING EDGE OF EXPOSED WING             XOF=557.644 IN

6. LANDING PERFORMANCE
      MINIMUM LANDING SPEED (W/40K PL)                          157.7 KT
      STATIC MARGIN (SUBSONIC)   (W/40K PL)                     -.0786
      STATIC MARGIN (SUBSONIC)   (W/O PL)                       -.0324
      TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)                 .5733

7. HYPERSONIC AERODYNAMIC TRIM DATA
      TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG                    30.86  DEG
```

ODIN Wing W_{14}

```
1. OVERALL CONFIGURATION
     AREA, PLANFORM (SFT)                                            5089.8
     LENGTH, NOSE TO WING LE AT BODY                                 505.20 IN
     LENGTH, NOSE TO WING C/4                                        894.06 IN
     ANGLE, GROUND PLANE                               *FIXED*       17.00 DEG

2. FUSELAGE
     AREA, WETTED                                      *FIXED*       6307.0 SFT
     LENGTH, NOSE TO END OF BODY                       *FIXED*       1315.0 IN

3. WING
     AREA, THEORETICAL OR TOTAL                                      4951.7 SFT
     AREA, ELEVON                                                    765.28 SFT
     SPAN                                                            1017.6 IN
     CHORD, MEAN AERODYNAMIC                                         826.47 IN
     CHORD, CENTERLINE ROOT                                          1214.8 IN
     CHORD, TIP                                                      186.65 IN
     TAPER RATIO, THEORETICAL                                        .15365
     ASPECT RATIO, THEORETICAL                                       1.4522
     ASPECT RATIO, EXPOSED SPAN                                      1.3613
     ANGLE, LEADING EDGE SWEEP                                       63.669 DEG
     ANGLE, TRAILING EDGE SWEEP                        *FIXED*          0.0 DEG
     ANGLE, DIHEDRAL                                   *FIXED*          7.0 DEG
     ANGLE, INCIDENCE                                  *FIXED*          1.5 DEG
     AIRFOIL SECTION, ROOT                             *FIXED*       008-64
     AIRFOIL SECTION, TIP                              *FIXED*       008-64

4. 040A MASS PROPERTIES
     FLIGHT CONDITION           WEIGHT (LB)      X-CG (FT)       X-CG (PC L)
     ORBITER LNDG (W/40K PL)    208119.6         74.249          67.758
     ORBITER LNDG (W/O PL)      168119.6         77.203          70.454
     WING WEIGHT                17254.2
     TPS WEIGHT                 34759.4

5. PRINCIPAL PARAMETERS
     X-SCALE FACTOR                                       SCLX= 1.4000
     Y-SCALE FACTOR                                       SCLY= 1.2000
     DISTANCE TO LEADING EDGE OF EXPOSED WING              XCF=505.200 IN

6. LANDING PERFORMANCE
     MINIMUM LANDING SPEED (W/40K PL)                                157.0 KT
     STATIC MARGIN (SUBSONIC)    (W/40K PL)                          -.0741
     STATIC MARGIN (SUBSONIC)    (W/O PL)                            -.0312
     TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)                       .5037

7. HYPERSONIC AERODYNAMIC TRIM DATA
     TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG                          28.33  DEG
```

ODIN Wing W_{15}

```
1. OVERALL CONFIGURATION
      AREA, PLANFORM (SFT)                                              5572.2
      LENGTH, NOSE TO WING LE AT BODY                                   457.88 IN
      LENGTH, NOSE TO WING C/4                                          902.29 IN
      ANGLE, GROUND PLANE                                     *FIXED*   17.00 DEG

2. FUSELAGE
      AREA, WETTED                                            *FIXED*   6307.0 SFT
      LENGTH, NOSE TO END OF BODY                             *FIXED*   1315.0 IN

3. WING
      AREA, THEORETICAL OR TOTAL                                        5659.1 SFT
      AREA, ELEVON                                                      874.60 SFT
      SPAN                                                              1017.6 IN
      CHORD, MEAN AERODYNAMIC                                           944.53 IN
      CHORD, CENTERLINE ROOT                                            1388.3 IN
      CHORD, TIP                                                        213.31 IN
      TAPER RATIO, THEORETICAL                                          .15365
      ASPECT RATIO, THEORETICAL                                         1.2707
      ASPECT RATIO, EXPOSED SPAN                                        1.1911
      ANGLE, LEADING EDGE SWEEP                                         66.585 DEG
      ANGLE, TRAILING EDGE SWEEP                              *FIXED*      0.0 DEG
      ANGLE, DIHEDRAL                                         *FIXED*      7.0 DEG
      ANGLE, INCIDENCE                                        *FIXED*      1.5 DEG
      AIRFOIL SECTION, ROOT                                   *FIXED*   008-64
      AIRFOIL SECTION, TIP                                    *FIXED*   008-64

4. 040A MASS PROPERTIES
      FLIGHT CONDITION              WEIGHT (LB)     X-CG (FT)         X-CG (PC L)
      ORBITER LNDG (W/40K PL)       211440.1        75.640            69.027
      ORBITER LNDG (W/0 PL)         171440.1        78.861            71.967
      WING WEIGHT                   17715.5
      TPS WEIGHT                    37618.6

5. PRINCIPAL PARAMETERS
      X-SCALE FACTOR                                            SCLX= 1.6000
      Y-SCALE FACTOR                                            SCLY= 1.2000
      DISTANCE TO LEADING EDGE OF EXPOSED WING                   XOF=457.883 IN

6. LANDING PERFORMANCE
      MINIMUM LANDING SPEED (W/40K PL)                                157.2 KT
      STATIC MARGIN (SUBSONIC)    (W/40K PL)                          -.0725
      STATIC MARGIN (SUBSONIC)    (W/O PL)                            -.0316
      TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)                       .4462

7. HYPERSONIC AERODYNAMIC TRIM DATA
      TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG                          26.74   DEG
```

ODIN Wing W_{16}

```
1. OVERALL CONFIGURATION
      AREA, PLANFORM (SFT)                                              3964.2
      LENGTH, NOSE TO WING LE AT BODY                                   658.86 IN
      LENGTH, NOSE TO WING C/4                                          889.32 IN
      ANGLE, GROUND PLANE                                   *FIXED*     17.00 DEG

2. FUSELAGE
      AREA, WETTED                                          *FIXED*     6307.0 SFT
      LENGTH, NOSE TO END OF BODY                           *FIXED*     1315.0 IN

3. WING
      AREA, THEORETICAL OR TOTAL                                        3139.3 SFT
      AREA, ELEVON                                                      510.18 SFT
      SPAN                                                              1153.2 IN
      CHORD, MEAN AERODYNAMIC                                           461.25 IN
      CHORD, CENTERLINE ROOT                                            677.33 IN
      CHORD, TIP                                                        106.66 IN
      TAPER RATIO, THEORETICAL                                          .15746
      ASPECT RATIO, THEORETICAL                                         2.9419
      ASPECT RATIO, EXPOSED SPAN                                        2.7793
      ANGLE, LEADING EDGE SWEEP                                         44.703 DEG
      ANGLE, TRAILING EDGE SWEEP                            *FIXED*        0.0 DEG
      ANGLE, DIHEDRAL                                       *FIXED*        7.0 DEG
      ANGLE, INCIDENCE                                      *FIXED*        1.5 DEG
      AIRFOIL SECTION, ROOT                                 *FIXED*     008-64
      AIRFOIL SECTION, TIP                                  *FIXED*     008-64

4. 040A MASS PROPERTIES
      FLIGHT CONDITION             WEIGHT (LB)      X-CG (FT)       X-CG (PC L)
      ORBITER LNDG (W/40K PL)      201628.5         71.277          65.046
      ORBITER LNDG (W/O PL)        161628.5         73.614          67.179
      WING WEIGHT                  17679.7
      TPS WEIGHT                   27842.8

5. PRINCIPAL PARAMETERS
      X-SCALE FACTOR                                             SCLX= .80000
      Y-SCALE FACTOR                                             SCLY= 1.4000
      DISTANCE TO LEADING EDGE OF EXPOSED WING                    XCF=658.861 IN

6. LANDING PERFORMANCE
      MINIMUM LANDING SPEED (W/40K PL)                                 147.0 KT
      STATIC MARGIN (SUBSONIC)    (W/40K PL)                           -.0891
      STATIC MARGIN (SUBSONIC)    (W/O PL)                             -.0283
      TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)                        .8772

7. HYPERSONIC AERODYNAMIC TRIM DATA
      TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG                           43.87  DEG
```

ODIN Wing W_{17}

1. OVERALL CONFIGURATION

AREA, PLANFORM (SFT)		4527.0
LENGTH, NOSE TO WING LE AT BODY		600.61 IN
LENGTH, NOSE TO WING C/4		888.69 IN
ANGLE, GROUND PLANE	*FIXED*	17.00 DEG

2. FUSELAGE

AREA, WETTED	*FIXED*	6307.0 SFT
LENGTH, NOSE TO END OF BODY	*FIXED*	1315.0 IN

3. WING

AREA, THEORETICAL OR TOTAL		3924.1 SFT
AREA, ELEVON		637.73 SFT
SPAN		1153.2 IN
CHORD, MEAN AERODYNAMIC		576.57 IN
CHORD, CENTERLINE ROOT		846.67 IN
CHORD, TIP		133.32 IN
TAPER RATIO, THEORETICAL		.15746
ASPECT RATIO, THEORETICAL		2.3535
ASPECT RATIO, EXPOSED SPAN		2.2235
ANGLE, LEADING EDGE SWEEP		51.050 DEG
ANGLE, TRAILING EDGE SWEEP	*FIXED*	0.0 DEG
ANGLE, DIHEDRAL	*FIXED*	7.0 DEG
ANGLE, INCIDENCE	*FIXED*	1.5 DEG
AIRFOIL SECTION, ROOT	*FIXED*	008-64
AIRFOIL SECTION, TIP	*FIXED*	008-64

4. 040A MASS PROPERTIES

FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC L)
ORBITER ENDG (W/40K PL)	205210.0	72.199	65.887
ORBITER ENDG (W/O PL)	165210.0	74.709	68.178
WING WEIGHT	18023.7		
TPS WEIGHT	31080.3		

5. PRINCIPAL PARAMETERS

X-SCALE FACTOR	SCLX= 1.0000
Y-SCALE FACTOR	SCLY= 1.4000
DISTANCE TO LEADING EDGE OF EXPOSED WING	XOF=600.614 IN

6. LANDING PERFORMANCE

MINIMUM LANDING SPEED (W/40K PL)	143.2 KT
STATIC MARGIN (SUBSONIC) (W/40K PL)	-.0800
STATIC MARGIN (SUBSONIC) (W/O PL)	-.0277
TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)	.7534

7. HYPERSONIC AERODYNAMIC TRIM DATA

TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG	34.12 DEG

ODIN Wing W_{18}

1. OVERALL CONFIGURATION

AREA, PLANFORM (SFT)		5089.8
LENGTH, NOSE TO WING LE AT BODY		549.15 IN
LENGTH, NOSE TO WING C/4		854.84 IN
ANGLE, GROUND PLANE	*FIXED*	17.00 DEG

2. FUSELAGE

AREA, WETTED	*FIXED*	6307.0 SFT
LENGTH, NOSE TO END OF BODY	*FIXED*	1315.0 IN

3. WING

AREA, THEORETICAL OR TOTAL		4708.9 SFT
AREA, ELEVON		765.28 SFT
SPAN		1153.2 IN
CHORD, MEAN AERODYNAMIC		691.88 IN
CHORD, CENTERLINE ROOT		1016.0 IN
CHORD, TIP		159.98 IN
TAPER RATIO, THEORETICAL		.15746
ASPECT RATIO, THEORETICAL		1.9612
ASPECT RATIO, EXPOSED SPAN		1.8529
ANGLE, LEADING EDGE SWEEP		56.035 DEG
ANGLE, TRAILING EDGE SWEEP	*FIXED*	0.0 DEG
ANGLE, DIHEDRAL	*FIXED*	7.0 DEG
ANGLE, INCIDENCE	*FIXED*	1.5 DEG
AIRFOIL SECTION, ROOT	*FIXED*	008-64
AIRFOIL SECTION, TIP	*FIXED*	008-64

4. 040A MASS PROPERTIES

FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC L)
ORBITER LNDG (W/40K PL)	208841.9	73.343	66.931
ORBITER LNDG (W/O PL)	168841.9	76.069	69.419
WING WEIGHT	18408.3		
TPS WEIGHT	34327.6		

5. PRINCIPAL PARAMETERS

X-SCALE FACTOR	SCLX= 1.2000
Y-SCALE FACTOR	SCLY= 1.4000
DISTANCE TO LEADING EDGE OF EXPOSED WING	XOF=549.145 IN

6. LANDING PERFORMANCE

MINIMUM LANDING SPEED (W/40K PL)	142.1 KT
STATIC MARGIN (SUBSONIC) (W/40K PL)	-.0779
STATIC MARGIN (SUBSONIC) (W/O PL)	-.0306
TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)	.6490

7. HYPERSONIC AERODYNAMIC TRIM DATA

TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG	29.53 DEG

ODIN Wing W_{19}

```
1. OVERALL CONFIGURATION
     AREA, PLANFORM (SFT)                                        5652.6
     LENGTH, NOSE TO WING LE AT BODY                             498.90 IN
     LENGTH, NOSE TO WING C/4                                    902.21 IN
     ANGLE, GROUND PLANE                               *FIXED*   17.00 DEG

2. FUSELAGE
     AREA, WETTED                                      *FIXED*   6307.0 SFT
     LENGTH, NOSE TO END OF BODY                       *FIXED*   1315.0 IN

3. WING
     AREA, THEORETICAL OR TOTAL                                  5493.7 SFT
     AREA, ELEVON                                                892.82 SFT
     SPAN                                                        1153.2 IN
     CHORD, MEAN AERODYNAMIC                                     807.19 IN
     CHORD, CENTERLINE ROOT                                      1185.3 IN
     CHORD, TIP                                                  186.65 IN
     TAPER RATIO, THEORETICAL                                    .15746
     ASPECT RATIO, THEORETICAL                                   1.6811
     ASPECT RATIO, EXPOSED SPAN                                  1.5882
     ANGLE, LEADING EDGE SWEEP                                   59.998 DEG
     ANGLE, TRAILING EDGE SWEEP                        *FIXED*      0.0 DEG
     ANGLE, DIHEDRAL                                   *FIXED*      7.0 DEG
     ANGLE, INCIDENCE                                  *FIXED*      1.5 DEG
     AIRFOIL SECTION, ROOT                             *FIXED*   008-64
     AIRFOIL SECTION, TIP                              *FIXED*   008-64

4. 040A MASS PROPERTIES
     FLIGHT CONDITION           WEIGHT (LB)      X-CG (FT)       X-CG (PC L)
     ORBITER LNDG (W/40K PL)    212508.6         74.636          68.111
     ORBITER LNDG (W/O PL)      172508.6         77.605          70.820
     WING WEIGHT                18821.4
     TPS WEIGHT                 37581.2

5. PRINCIPAL PARAMETERS
     X-SCALE FACTOR                                       SCLX= 1.4000
     Y-SCALE FACTOR                                       SCLY= 1.4000
     DISTANCE TO LEADING EDGE OF EXPOSED WING              XOF=498.903 IN

6. LANDING PERFORMANCE
     MINIMUM LANDING SPEED (W/40K PL)                           141.4 KT
     STATIC MARGIN (SUBSONIC)    (W/40K PL)                     -.0752
     STATIC MARGIN (SUBSONIC)    (W/O PL)                       -.0311
     TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)                  .5711

7. HYPERSONIC AERODYNAMIC TRIM DATA
     TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG                     27.36  DEG
```

ODIN Wing W_{20}

1. OVERALL CONFIGURATION		
AREA, PLANFORM (SFT)		6215.4
LENGTH, NOSE TO WING LE AT BODY		451.62 IN
LENGTH, NOSE TO WING C/4		912.54 IN
ANGLE, GROUND PLANE	*FIXED*	17.00 DEG
2. FUSELAGE		
AREA, WETTED	*FIXED*	6307.0 SFT
LENGTH, NOSE TO END OF BODY	*FIXED*	1315.0 IN
3. WING		
AREA, THEORETICAL OR TOTAL		6278.5 SFT
AREA, ELEVON		1020.4 SFT
SPAN		1153.2 IN
CHORD, MEAN AERODYNAMIC		922.51 IN
CHORD, CENTERLINE ROOT		1354.7 IN
CHORD, TIP		213.31 IN
TAPER RATIO, THEORETICAL		.15746
ASPECT RATIO, THEORETICAL		1.4709
ASPECT RATIO, EXPOSED SPAN		1.3897
ANGLE, LEADING EDGE SWEEP		63.196 DEG
ANGLE, TRAILING EDGE SWEEP	*FIXED*	0.0 DEG
ANGLE, DIHEDRAL	*FIXED*	7.0 DEG
ANGLE, INCIDENCE	*FIXED*	1.5 DEG
AIRFOIL SECTION, ROOT	*FIXED*	008-64
AIRFOIL SECTION, TIP	*FIXED*	008-64

4. 040A MASS PROPERTIES

FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC L)
ORBITER LNDG (W/40K PL)	216198.1	76.106	69.453
ORBITER LNDG (W/O PL)	176198.1	79.346	72.410
WING WEIGHT	19253.1		
TPS WEIGHT	40839.0		

5. PRINCIPAL PARAMETERS	
X-SCALE FACTOR	SCLX= 1.6000
Y-SCALE FACTOR	SCLY= 1.4000
DISTANCE TO LEADING EDGE OF EXPOSED WING	XOF=451.616 IN
6. LANDING PERFORMANCE	
MINIMUM LANDING SPEED (W/40K PL)	141.4 KT
STATIC MARGIN (SUBSONIC) (W/40K PL)	-.0735
STATIC MARGIN (SUBSONIC) (W/O PL)	-.0314
TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)	.5086
7. HYPERSONIC AERODYNAMIC TRIM DATA	
TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG	26.10 DEG

ODIN Wing W_{21}

1. OVERALL CONFIGURATION

AREA, PLANFORM (SFT)		4285.8
LENGTH, NOSE TO WING LE AT BODY		654.40 IN
LENGTH, NOSE TO WING C/4		891.05 IN
ANGLE, GROUND PLANE	*FIXED*	17.00 DEG

2. FUSELAGE

AREA, WETTED	*FIXED*	6307.0 SFT
LENGTH, NOSE TO END OF BODY	*FIXED*	1315.0 IN

3. WING

AREA, THEORETICAL OR TOTAL		3451.9 SFT
AREA, ELEVON		583.07 SFT
SPAN		1288.8 IN
CHORD, MEAN AERODYNAMIC		453.00 IN
CHORD, CENTERLINE ROOT		664.72 IN
CHORD, TIP		106.66 IN
TAPER RATIO, THEORETICAL		.16045
ASPECT RATIO, THEORETICAL		3.3416
ASPECT RATIO, EXPOSED SPAN		3.1764
ANGLE, LEADING EDGE SWEEP		40.892 DEG
ANGLE, TRAILING EDGE SWEEP	*FIXED*	0.0 DEG
ANGLE, DIHEDRAL	*FIXED*	7.0 DEG
ANGLE, INCIDENCE	*FIXED*	1.5 DEG
AIRFOIL SECTION, ROOT	*FIXED*	008-64
AIRFOIL SECTION, TIP	*FIXED*	008-64

4. 040A MASS PROPERTIES

FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC L)
ORBITER LNDG (W/40K PL)	204924.5	71.471	65.223
ORBITER LNDG (W/O PL)	164924.5	73.809	67.356
WING WEIGHT	19336.9		
TPS WEIGHT	29481.6		

5. PRINCIPAL PARAMETERS

X-SCALE FACTOR	SCLX= .80000
Y-SCALE FACTOR	SCLY= 1.6000
DISTANCE TO LEADING EDGE OF EXPOSED WING	XCF=654.398 IN

6. LANDING PERFORMANCE

MINIMUM LANDING SPEED (W/40K PL)	136.3 KT
STATIC MARGIN (SUBSONIC) (W/40K PL)	-.0906
STATIC MARGIN (SUBSONIC) (W/O PL)	-.0287
TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)	.9438

7. HYPERSONIC AERODYNAMIC TRIM DATA

TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG	39.93 DEG

ODIN Wing W_{22}

```
1. OVERALL CONFIGURATION
      AREA, PLANFORM (SFT)                                            4929.0
      LENGTH, NOSE TO WING LE AT BODY                                 598.27 IN
      LENGTH, NOSE TO WING C/4                                        894.09 IN
      ANGLE, GROUND PLANE                                  *FIXED*    17.00 DEG

2. FUSELAGE
      AREA, WETTED                                         *FIXED*    6307.0 SFT
      LENGTH, NOSE TO END OF BODY                          *FIXED*    1315.0 IN

3. WING
      AREA, THEORETICAL OR TOTAL                                      4314.9 SFT
      AREA, ELEVON                                                    728.84 SFT
      SPAN                                                            1288.8 IN
      CHORD, MEAN AERODYNAMIC                                         566.25 IN
      CHORD, CENTERLINE ROOT                                          830.89 IN
      CHORD, TIP                                                      133.32 IN
      TAPER RATIO, THEORETICAL                                        .16045
      ASPECT RATIO, THEORETICAL                                       2.6732
      ASPECT RATIO, EXPOSED SPAN                                      2.5411
      ANGLE, LEADING EDGE SWEEP                                       47.268 DEG
      ANGLE, TRAILING EDGE SWEEP                           *FIXED*       0.0 DEG
      ANGLE, DIHEDRAL                                      *FIXED*       7.0 DEG
      ANGLE, INCIDENCE                                     *FIXED*       1.5 DEG
      AIRFOIL SECTION, ROOT                                *FIXED*    008-64
      AIRFOIL SECTION, TIP                                 *FIXED*    008-64

4. 040A MASS PROPERTIES
      FLIGHT CONDITION           WEIGHT (LB)      X-CG (FT)       X-CG (PC L)
      ORBITER LNDG (W/40K PL)    208864.9         72.478          66.141
      ORBITER LNDG (W/O PL)      168864.9         74.999          68.442
      WING WEIGHT                19642.3
      TPS WEIGHT                 33116.7

5. PRINCIPAL PARAMETERS
      X-SCALE FACTOR                                     SCLX= 1.0000
      Y-SCALE FACTOR                                     SCLY= 1.6000
      DISTANCE TO LEADING EDGE OF EXPOSED WING            XOF=598.269 IN

6. LANDING PERFORMANCE
      MINIMUM LANDING SPEED (W/40K PL)                                132.0 KT
      STATIC MARGIN (SUBSONIC)    (W/40K PL)                          -.0821
      STATIC MARGIN (SUBSONIC)    (W/O PL)                            -.0287
      TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)                       .8204

7. HYPERSONIC AERODYNAMIC TRIM DATA
      TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG                          31.79  DEG
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ODIN Wing W_{23}

```
1. OVERALL CONFIGURATION
      AREA, PLANFORM (SFT)                                            5572.2
      LENGTH, NOSE TO WING LE AT BODY                                 549.09 IN
      LENGTH, NOSE TO WING C/4                                        904.07 IN
      ANGLE, GROUND PLANE                                 *FIXED*     17.00 DEG

2. FUSELAGE
      AREA, WETTED                                        *FIXED*     6307.0 SFT
      LENGTH, NOSE TO END OF BODY                         *FIXED*     1315.0 IN

3. WING
      AREA, THEORETICAL OR TOTAL                                      5177.9 SFT
      AREA, ELEVON                                                    874.60 SFT
      SPAN                                                            1288.8 IN
      CHORD, MEAN AERODYNAMIC                                         679.50 IN
      CHORD, CENTERLINE ROOT                                          997.07 IN
      CHORD, TIP                                                      159.98 IN
      TAPER RATIO, THEORETICAL                                        .16045
      ASPECT RATIO, THEORETICAL                                       2.2277
      ASPECT RATIO, EXPOSED SPAN                                      2.1176
      ANGLE, LEADING EDGE SWEEP                                       52.409 DEG
      ANGLE, TRAILING EDGE SWEEP                          *FIXED*        0.0 DEG
      ANGLE, DIHEDRAL                                     *FIXED*        7.0 DEG
      ANGLE, INCIDENCE                                    *FIXED*        1.5 DEG
      AIRFOIL SECTION, ROOT                               *FIXED*     008-64
      AIRFOIL SECTION, TIP                                *FIXED*     008-64

4. 040A MASS PROPERTIES
      FLIGHT CONDITION            WEIGHT (LB)     X-CG (FT)        X-CG (PC L)
      ORBITER LNDG (W/40K PL)     212858.0        73.723           67.278
      ORBITER LNDG (W/O PL)       172858.0        76.475           69.789
      WING WEIGHT                 19989.2
      TPS WEIGHT                  36762.8

5. PRINCIPAL PARAMETERS
      X-SCALE FACTOR                                           SCLX= 1.2000
      Y-SCALE FACTOR                                           SCLY= 1.6000
      DISTANCE TO LEADING EDGE OF EXPOSED WING                  XOF=549.090 IN

6. LANDING PERFORMANCE
      MINIMUM LANDING SPEED (W/40K PL)                                130.6 KT
      STATIC MARGIN (SUBSONIC)    (W/40K PL)                          -.0810
      STATIC MARGIN (SUBSONIC)    (W/O PL)                            -.0324
      TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)                       .7113

7. HYPERSONIC AERODYNAMIC TRIM DATA
      TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG                          28.05  DEG
```

ODIN Wing W_{24}

1. OVERALL CONFIGURATION

AREA, PLANFORM (SFT)		6215.4
LENGTH, NOSE TO WING LE AT BODY		497.01 IN
LENGTH, NOSE TO WING C/4		911.15 IN
ANGLE, GROUND PLANE	*FIXED*	17.00 DEG

2. FUSELAGE

AREA, WETTED	*FIXED*	6307.0 SFT
LENGTH, NOSE TO END OF BODY	*FIXED*	1315.0 IN

3. WING

AREA, THEORETICAL OR TOTAL		6040.8 SFT
AREA, ELEVON		1020.4 SFT
SPAN		1288.8 IN
CHORD, MEAN AERODYNAMIC		792.75 IN
CHORD, CENTERLINE ROOT		1163.3 IN
CHORD, TIP		186.65 IN
TAPER RATIO, THEORETICAL		.16045
ASPECT RATIO, THEORETICAL		1.9095
ASPECT RATIO, EXPOSED SPAN		1.8151
ANGLE, LEADING EDGE SWEEP		56.580 DEG
ANGLE, TRAILING EDGE SWEEP	*FIXED*	0.0 DEG
ANGLE, DIHEDRAL	*FIXED*	7.0 DEG
ANGLE, INCIDENCE	*FIXED*	1.5 DEG
AIRFOIL SECTION, ROOT	*FIXED*	008-64
AIRFOIL SECTION, TIP	*FIXED*	008-64

4. 040A MASS PROPERTIES

FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC L)
ORBITER LNDG (W/40K PL)	216889.8	75.059	68.497
ORBITER LNDG (W/O PL)	176889.8	78.050	71.226
WING WEIGHT	20367.7		
TPS WEIGHT	40416.0		

5. PRINCIPAL PARAMETERS

X-SCALE FACTOR	SCLX= 1.4000
Y-SCALE FACTOR	SCLY= 1.6000
DISTANCE TO LEADING EDGE OF EXPOSED WING	XOF=497.008 IN

6. LANDING PERFORMANCE

MINIMUM LANDING SPEED (W/40K PL)	129.3 KT
STATIC MARGIN (SUBSONIC) (W/40K PL)	-.0762
STATIC MARGIN (SUBSONIC) (W/O PL)	-.0310
TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)	.6343

7. HYPERSONIC AERODYNAMIC TRIM DATA

TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG	26.57 DEG

ODIN Wing W_{25}

1. OVERALL CONFIGURATION

AREA, PLANFORM (SFT)		6858.6
LENGTH, NOSE TO WING LE AT BODY		450.04 IN
LENGTH, NOSE TO WING C/4		923.35 IN
ANGLE, GROUND PLANE	*FIXED*	17.00 DEG

2. FUSELAGE

AREA, WETTED	*FIXED*	6307.0 SFT
LENGTH, NOSE TO END OF BODY	*FIXED*	1315.0 IN

3. WING

AREA, THEORETICAL OR TOTAL		6903.8 SFT
AREA, ELEVON		1166.1 SFT
SPAN		1288.8 IN
CHORD, MEAN AERODYNAMIC		906.00 IN
CHORD, CENTERLINE ROOT		1329.4 IN
CHORD, TIP		213.31 IN
TAPER RATIO, THEORETICAL		.16045
ASPECT RATIO, THEORETICAL		1.6708
ASPECT RATIO, EXPOSED SPAN		1.5882
ANGLE, LEADING EDGE SWEEP		59.998 DEG
ANGLE, TRAILING EDGE SWEEP	*FIXED*	0.0 DEG
ANGLE, DIHEDRAL	*FIXED*	7.0 DEG
ANGLE, INCIDENCE	*FIXED*	1.5 DEG
AIRFOIL SECTION, ROOT	*FIXED*	008-64
AIRFOIL SECTION, TIP	*FIXED*	008-64

4. 040A MASS PROPERTIES

FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC L)
ORBITER LNDG (W/40K PL)	220949.2	76.612	69.914
ORBITER LNDG (W/O PL)	180949.2	79.879	72.896
WING WEIGHT	20769.3		
TPS WEIGHT	44073.9		

5. PRINCIPAL PARAMETERS

X-SCALE FACTOR	SCLX= 1.6000
Y-SCALE FACTOR	SCLY= 1.6000
DISTANCE TO LEADING EDGE OF EXPOSED WING	XOF=450.039 IN

6. LANDING PERFORMANCE

MINIMUM LANDING SPEED (W/40K PL)	129.0 KT
STATIC MARGIN (SUBSONIC) (W/40K PL)	-.0745
STATIC MARGIN (SUBSONIC) (W/O PL)	-.0312
TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)	.5678

7. HYPERSONIC AERODYNAMIC TRIM DATA

TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG	25.58 DEG

ODIN Wing W_{26}

1. OVERALL CONFIGURATION

AREA, PLANFORM (SFT)		3702.9
LENGTH, NOSE TO WING LE AT BODY		642.36 IN
LENGTH, NOSE TO WING C/4		886.42 IN
ANGLE, GROUND PLANE	*FIXED*	17.00 DEG

2. FUSELAGE

AREA, WETTED	*FIXED*	6307.0 SFT
LENGTH, NOSE TO END OF BODY	*FIXED*	1315.0 IN

3. WING

AREA, THEORETICAL OR TOTAL		3010.9 SFT
AREA, ELEVON		450.97 SFT
SPAN		949.80 IN
CHORD, MEAN AERODYNAMIC		539.19 IN
CHORD, CENTERLINE ROOT		792.98 IN
CHORD, TIP		119.99 IN
TAPER RATIO, THEORETICAL		.15131
ASPECT RATIO, THEORETICAL		2.0807
ASPECT RATIO, EXPOSED SPAN		1.9411
ANGLE, LEADING EDGE SWEEP		54.790 DEG
ANGLE, TRAILING EDGE SWEEP	*FIXED*	0.0 DEG
ANGLE, DIHEDRAL	*FIXED*	7.0 DEG
ANGLE, INCIDENCE	*FIXED*	1.5 DEG
AIRFOIL SECTION, ROOT	*FIXED*	008-64
AIRFOIL SECTION, TIP	*FIXED*	008-64

4. 040A MASS PROPERTIES

FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC L)
ORBITER LNDG (W/40K PL)	198158.8	71.412	65.169
ORBITER LNDG (W/O PL)	158158.8	73.835	67.380
WING WEIGHT	15331.4		
TPS WEIGHT	26721.3		

5. PRINCIPAL PARAMETERS

X-SCALE FACTOR	SCLX= .90000
Y-SCALE FACTOR	SCLY= 1.1000
DISTANCE TO LEADING EDGE OF EXPOSED WING	XOF=642.360 IN

6. LANDING PERFORMANCE

MINIMUM LANDING SPEED (W/40K PL)	167.6 KT
STATIC MARGIN (SUBSONIC) (W/40K PL)	-.0817
STATIC MARGIN (SUBSONIC) (W/O PL)	-.0278
TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)	.6916

7. HYPERSONIC AERODYNAMIC TRIM DATA

TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG	44.09 DEG

ODIN Wing W_{27}

```
1. OVERALL CONFIGURATION
        AREA, PLANFORM (SFT)                                        4064.7
        LENGTH, NOSE TO WING LE AT BODY                             630.36 IN
        LENGTH, NOSE TO WING C/4                                    885.34 IN
        ANGLE, GROUND PLANE                              *FIXED*    17.00 DEG

2. FUSELAGE
        AREA, WETTED                                     *FIXED*    6307.0 SFT
        LENGTH, NOSE TO END OF BODY                      *FIXED*    1315.0 IN

3. WING
        AREA, THEORETICAL OR TOTAL                                  3356.9 SFT
        AREA, ELEVON                                                532.96 SFT
        SPAN                                                        1085.4 IN
        CHORD, MEAN AERODYNAMIC                                     524.63 IN
        CHORD, CENTERLINE ROOT                                      770.74 IN
        CHORD, TIP                                                  119.99 IN
        TAPER RATIO, THEORETICAL                                    .15568
        ASPECT RATIO, THEORETICAL                                   2.4371
        ASPECT RATIO, EXPOSED SPAN                                  2.2940
        ANGLE, LEADING EDGE SWEEP                                   50.172 DEG
        ANGLE, TRAILING EDGE SWEEP                       *FIXED*       0.0 DEG
        ANGLE, DIHEDRAL                                  *FIXED*       7.0 DEG
        ANGLE, INCIDENCE                                 *FIXED*       1.5 DEG
        AIRFOIL SECTION, ROOT                            *FIXED*    008-64
        AIRFOIL SECTION, TIP                             *FIXED*    008-64

4. 040A MASS PROPERTIES
        FLIGHT CONDITION            WEIGHT (LB)     X-CG (FT)       X-CG (PC L)
        ORBITER LNDG (W/40K PL)     201665.9        71.584          65.326
        ORBITER LNDG (W/O PL)       161665.9        73.996          67.527
        WING WEIGHT                 17015.6
        TPS WEIGHT                  28544.3

5. PRINCIPAL PARAMETERS
        X-SCALE FACTOR                                   SCLX= .90000
        Y-SCALE FACTOR                                   SCLY= 1.3000
        DISTANCE TO LEADING EDGE OF EXPOSED WING          XOF=630.360 IN

6. LANDING PERFORMANCE
        MINIMUM LANDING SPEED (W/40K PL)                         150.8 KT
        STATIC MARGIN (SUBSONIC)    (W/40K PL)                   -.0806
        STATIC MARGIN (SUBSONIC)    (W/O PL)                     -.0254
        TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)                .7799

7. HYPERSONIC AERODYNAMIC TRIM DATA
        TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG                   40.36  DEG
```

ODIN Wing W_{28}

1. OVERALL CONFIGURATION

AREA, PLANFORM (SFT)		4426.5
LENGTH, NOSE TO WING LE AT BODY		626.27 IN
LENGTH, NOSE TO WING C/4		889.25 IN
ANGLE, GROUND PLANE	*FIXED*	17.00 DEG

2. FUSELAGE

AREA, WETTED	*FIXED*	6307.0 SFT
LENGTH, NOSE TO END OF BODY	*FIXED*	1315.0 IN

3. WING

AREA, THEORETICAL OR TOTAL		3707.2 SFT
AREA, ELEVON		614.95 SFT
SPAN		1221.0 IN
CHORD, MEAN AERODYNAMIC		513.96 IN
CHORD, CENTERLINE ROOT		754.43 IN
CHORD, TIP		119.99 IN
TAPER RATIO, THEORETICAL		.15904
ASPECT RATIO, THEORETICAL		2.7927
ASPECT RATIO, EXPOSED SPAN		2.6470
ANGLE, LEADING EDGE SWEEP		46.101 DEG
ANGLE, TRAILING EDGE SWEEP	*FIXED*	0.0 DEG
ANGLE, DIHEDRAL	*FIXED*	7.0 DEG
ANGLE, INCIDENCE	*FIXED*	1.5 DEG
AIRFOIL SECTION, ROOT	*FIXED*	008-64
AIRFOIL SECTION, TIP	*FIXED*	008-64

4. 040A MASS PROPERTIES

FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC L)
ORBITER LNDG (W/40K PL)	205152.2	71.819	65.540
ORBITER LNDG (W/O PL)	165152.2	74.238	67.747
WING WEIGHT	18668.4		
TPS WEIGHT	30377.7		

5. PRINCIPAL PARAMETERS

X-SCALE FACTOR	SCLX= .90000
Y-SCALE FACTOR	SCLY= 1.5000
DISTANCE TO LEADING EDGE OF EXPOSED WING	XOF=626.268 IN

6. LANDING PERFORMANCE

MINIMUM LANDING SPEED (W/40K PL)	138.7 KT
STATIC MARGIN (SUBSONIC) (W/40K PL)	-.0837
STATIC MARGIN (SUBSONIC) (W/O PL)	-.0272
TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)	.8492

7. HYPERSONIC AERODYNAMIC TRIM DATA

TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG	36.55 DEG

ODIN Wing W_{29}

```
1. OVERALL CONFIGURATICN
      AREA, PLANFORM (SFT)                                    4587.3
      LENGTH, NOSE TO WING LE AT BODY                         580.70 IN
      LENGTH, NOSE TO WING C/4                                892.35 IN
      ANGLE, GROUND PLANE                          *FIXED*    17.00 DEG

2. FUSELAGE
      AREA, WETTED                                 *FIXED*    6307.0 SFT
      LENGTH, NOSE TO END CF BODY                  *FIXED*    1315.0 IN

3. WING
      AREA, THEORETICAL OR TOTAL                              4102.9 SFT
      AREA, ELEVON                                            651.40 SFT
      SPAN                                                    1085.4 IN
      CHORD, MEAN AERCDYNAMIC                                 641.21 IN
      CHORD, CENTERLINE ROOT                                  942.01 IN
      CHCRD, TIP                                              146.65 IN
      TAPER RATIO, THECRETICAL                                .15568
      ASPECT RATIO, THEORETICAL                               1.9940
      ASPECT RATIO, EXPOSED SPAN                              1.8769
      ANGLE, LEADING EDGE SWEEP                               55.692 DEG
      ANGLE, TRAILING EDGE SWEEP                   *FIXED*       0.0 DEG
      ANGLE, DIHECRAL                              *FIXED*       7.0 DEG
      ANGLE, INCIDENCE                             *FIXED*       1.5 DEG
      AIRFCIL SECTION, ROOT                        *FIXED*    008-64
      AIRFOIL SECTION, TIP                         *FIXED*    008-64

4. 040A MASS PROPERTIES
      FLIGHT CONDITION         WEIGHT (LB)    X-CG (FT)     X-CG (PC L)
      ORBITER LNDG (W/40K PL)  205097.8       72.652        66.301
      ORBITER LNDG (W/O PL)    165097.8       75.274        68.693
      WING WEIGHT              17403.0
      TPS WEIGHT               31588.8

5. PRINCIPAL PARAMETERS
      X-SCALE FACTOR                                  SCLX= 1.1000
      Y-SCALE FACTOR                                  SCLY= 1.3000
      DISTANCE TO LEADING EDGE OF EXPOSED WING        XOF=580.704 IN

6. LANDING PERFORMANCE
      MINIMUM LANCING SPEEC (W/40K PL)                       150.3 KT
      STATIC MARGIN (SUBSONIC)   (W/40K PL)                  -.0818
      STATIC MARGIN (SUBSONIC)   (W/O PL)                    -.0327
      TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)              .6537

7. HYPERSCNIC AERODYNAMIC TRIM DATA
      TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG                 31.84  DEG
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ODIN Wing W_{30}

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1. OVERALL CONFIGURATION
       AREA, PLANFORM (SFT)                                          4326.0
       LENGTH, NOSE TO WING LE AT BODY                               601.69 IN
       LENGTH, NOSE TO WING C/4                                      885.01 IN
       ANGLE, GROUND PLANE                               *FIXED*     17.00 DEG

2. FUSELAGE
       AREA, WETTED                                      *FIXED*     6307.0 SFT
       LENGTH, NOSE TO END OF BODY                       *FIXED*     1315.0 IN

3. WING
       AREA, THEORETICAL OR TOTAL                                    3729.9 SFT
       AREA, ELEVON                                                  592.18 SFT
       SPAN                                                          1085.4 IN
       CHORD, MEAN AERODYNAMIC                                       582.92 IN
       CHORD, CENTERLINE ROOT                                        856.38 IN
       CHORD, TIP                                                    133.32 IN
       TAPER RATIO, THEORETICAL                                      .15568
       ASPECT RATIO, THEORETICAL                                     2.1934
       ASPECT RATIO, EXPOSED SPAN                                    2.0646
       ANGLE, LEADING EDGE SWEEP                                     53.108 DEG
       ANGLE, TRAILING EDGE SWEEP                        *FIXED*        0.0 DEG
       ANGLE, DIHEDRAL                                   *FIXED*        7.0 DEG
       ANGLE, INCIDENCE                                  *FIXED*        1.5 DEG
       AIRFOIL SECTION, ROOT                             *FIXED*     008-64
       AIRFOIL SECTION, TIP                              *FIXED*     008-64

4. 040A MASS PROPERTIES
       FLIGHT CONDITION           WEIGHT (LB)      X-CG (FT)        X-CG (PC L)
       ORBITER LNDG (W/40K PL)    203375.9         72.052           65.753
       ORBITER LNDG (W/O PL)      163375.9         74.553           68.036
       WING WEIGHT                17204.5
       TPS WEIGHT                 30065.4

5. PRINCIPAL PARAMETERS
       X-SCALE FACTOR                                       SCLX=  1.0000
       Y-SCALE FACTOR                                       SCLY=  1.3000
       DISTANCE TO LEADING EDGE OF EXPOSED WING              XOF=601.694 IN

6. LANDING PERFORMANCE
       MINIMUM LANDING SPEED (W/40K PL)                              149.6 KT
       STATIC MARGIN (SUBSONIC)     (W/40K PL)                       -.0776
       STATIC MARGIN (SUBSONIC)     (W/O PL)                         -.0261
       TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)                     .7195

7. HYPERSONIC AERODYNAMIC TRIM DATA
       TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG                        35.82  DEG
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ODIN Wing W_{31}

```
1. OVERALL CONFIGURATION
     AREA, PLANFORM (SFT)                                            3883.8
     LENGTH, NOSE TO WING LE AT BODY                                 637.56 IN
     LENGTH, NOSE TO WING C/4                                        887.54 IN
     ANGLE, GROUND PLANE                                  *FIXED*    17.00 DEG

2. FUSELAGE
     AREA, WETTED                                         *FIXED*    6307.0 SFT
     LENGTH, NOSE TO END OF BODY                          *FIXED*    1315.0 IN

3. WING
     AREA, THEORETICAL OR TOTAL                                      3183.3 SFT
     AREA, ELEVON                                                    491.96 SFT
     SPAN                                                            1017.6 IN
     CHORD, MEAN AERODYNAMIC                                         531.30 IN
     CHORD, CENTERLINE ROOT                                          780.93 IN
     CHORD, TIP                                                      119.99 IN
     TAPER RATIO, THEORETICAL                                        .15365
     ASPECT RATIO, THEORETICAL                                       2.2590
     ASPECT RATIO, EXPOSED SPAN                                      2.1176
     ANGLE, LEADING EDGE SWEEP                                       52.409 DEG
     ANGLE, TRAILING EDGE SWEEP                           *FIXED*       0.0 DEG
     ANGLE, DIHEDRAL                                      *FIXED*       7.0 DEG
     ANGLE, INCIDENCE                                     *FIXED*       1.5 DEG
     AIRFOIL SECTION, ROOT                                *FIXED*    008-64
     AIRFOIL SECTION, TIP                                 *FIXED*    008-64

4. 040A MASS PROPERTIES
     FLIGHT CONDITION         WEIGHT (LB)     X-CG (FT)       X-CG (PC L)
     ORBITER LNDG (W/40K PL)  199915.0        71.517          65.265
     ORBITER LNDG (W/O PL)    159915.0        73.940          67.476
     WING WEIGHT              16177.7
     TPS WEIGHT               27631.3

5. PRINCIPAL PARAMETERS
     X-SCALE FACTOR                                         SCLX= .90000
     Y-SCALE FACTOR                                         SCLY= 1.2000
     DISTANCE TO LEADING EDGE OF EXPOSED WING                XOF=637.561 IN

6. LANDING PERFORMANCE
     MINIMUM LANDING SPEED (W/40K PL)                                159.2 KT
     STATIC MARGIN (SUBSONIC)   (W/40K PL)                           -.0836
     STATIC MARGIN (SUBSONIC)   (W/O PL)                             -.0289
     TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)                       .7314

7. HYPERSONIC AERODYNAMIC TRIM DATA
     TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG                          41.53  DEG
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ODIN Wing W_{32}

```
ODIN SUMMARY DATA, 040 A          PITCH.TRIM   PROBLEM          CYCLE     1
                                  .90000 1.4000 52.322          4/27/72

1. OVERALL CONFIGURATION
      AREA, PLANFORM (SFT)                                               4245.6
      LENGTH, NOSE TO WING LE AT BODY                                    627.86 IN
      LENGTH, NOSE TO WING C/4                                           887.14 IN
      ANGLE, GROUND PLANE                                   *FIXED*      17.00 DEG

2. FUSELAGE
      AREA, WETTED                                          *FIXED*      6307.0 SFT
      LENGTH, NOSE TO END OF BODY                           *FIXED*      1315.0 IN

3. WING
      AREA, THEORETICAL OR TOTAL                                         3531.7 SFT
      AREA, ELEVON                                                       573.96 SFT
      SPAN                                                               1153.2 IN
      CHORD, MEAN AERODYNAMIC                                            518.91 IN
      CHORD, CENTERLINE ROOT                                             762.00 IN
      CHORD, TIP                                                         119.99 IN
      TAPER RATIO, THEORETICAL                                           .15746
      ASPECT RATIO, THEORETICAL                                          2.6150
      ASPECT RATIO, EXPOSED SPAN                                         2.4705
      ANGLE, LEADING EDGE SWEEP                                          48.071 DEG
      ANGLE, TRAILING EDGE SWEEP                            *FIXED*         0.0 DEG
      ANGLE, DIHEDRAL                                       *FIXED*         7.0 DEG
      ANGLE, INCIDENCE                                      *FIXED*         1.5 DEG
      AIRFOIL SECTION, ROOT                                 *FIXED*      008-64
      AIRFOIL SECTION, TIP                                  *FIXED*      008-64

4. 040A MASS PROPERTIES
      FLIGHT CONDITION            WEIGHT (LB)     X-CG (FT)      X-CG (PC L)
      ORBITER LNDG (W/40K PL)     203411.8        71.698         65.430
      ORBITER LNDG (W/O PL)       163411.8        74.113         67.634
      WING WEIGHT                 17845.8
      TPS WEIGHT                  29460.0

5. PRINCIPAL PARAMETERS
      X-SCALE FACTOR                                        SCLX= .90000
      Y-SCALE FACTOR                                        SCLY= 1.4000
      DISTANCE TO LEADING EDGE OF EXPOSED WING               XCF=627.864 IN

6. LANDING PERFORMANCE
      MINIMUM LANDING SPEED (W/40K PL)                                  144.3 KT
      STATIC MARGIN (SUBSONIC)     (W/40K PL)                           -.0819
      STATIC MARGIN (SUBSONIC)     (W/O PL)                             -.0261
      TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)                         .8164

7. HYPERSONIC AERODYNAMIC TRIM DATA
      TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG                            38.33  DEG
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ODIN Wing W_{33}

1. OVERALL CONFIGURATION			
AREA, PLANFORM (SFT)			3803.4
LENGTH, NOSE TO WING LE AT BODY			663.70 IN
LENGTH, NOSE TO WING C/4			890.35 IN
ANGLE, GROUND PLANE		*FIXED*	17.00 DEG
2. FUSELAGE			
AREA, WETTED		*FIXED*	6307.0 SFT
LENGTH, NOSE TO END OF BODY		*FIXED*	1315.0 IN
3. WING			
AREA, THEORETICAL OR TOTAL			2984.0 SFT
AREA, ELEVON			473.74 SFT
SPAN			1085.4 IN
CHORD, MEAN AERODYNAMIC			466.34 IN
CHORD, CENTERLINE ROOT			685.10 IN
CHORD, TIP			106.66 IN
TAPER RATIO, THEORETICAL			.15568
ASPECT RATIO, THEORETICAL			2.7417
ASPECT RATIO, EXPOSED SPAN			2.5808
ANGLE, LEADING EDGE SWEEP			46.825 DEG
ANGLE, TRAILING EDGE SWEEP		*FIXED*	0.0 DEG
ANGLE, DIHEDRAL		*FIXED*	7.0 DEG
ANGLE, INCIDENCE		*FIXED*	1.5 DEG
AIRFOIL SECTION, ROOT		*FIXED*	008-64
AIRFOIL SECTION, TIP		*FIXED*	008-64
4. 040A MASS PROPERTIES			
FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC L)
ORBITER LNDG (W/40K PL)	199970.6	71.202	64.977
ORBITER LNDG (W/O PL)	159970.6	73.545	67.115
WING WEIGHT	16838.4		
TPS WEIGHT	27026.2		
5. PRINCIPAL PARAMETERS			
X-SCALE FACTOR			SCLX= .80000
Y-SCALE FACTOR			SCLY= 1.3000
DISTANCE TO LEADING EDGE OF EXPOSED WING			XOF=663.696 IN
6. LANDING PERFORMANCE			
MINIMUM LANDING SPEED (W/40K PL)			153.8 KT
STATIC MARGIN (SUBSONIC) (W/40K PL)			-.0900
STATIC MARGIN (SUBSONIC) (W/O PL)			-.0297
TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)			.8366
7. HYPERSONIC AERODYNAMIC TRIM DATA			
TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG			45.66 DEG

ODIN Wing W_{27} (Modified)

1. OVERALL CONFIGURATION		
AREA, PLANFORM (SFT)		4182.2
LENGTH, NOSE TO WING LE AT BODY		628.13 IN
LENGTH, NOSE TO WING C/4		889.39 IN
ANGLE, GROUND PLANE	*FIXED*	17.00 DEG
2. FUSELAGE		
AREA, WETTED	*FIXED*	6307.0 SFT
LENGTH, NOSE TO END OF BODY	*FIXED*	1315.0 IN
3. WING		
AREA, THEORETICAL OR TOTAL		3535.1 SFT
AREA, ELEVON		646.66 SFT
SPAN		1085.4 IN
CHORD, MEAN AERODYNAMIC		555.61 IN
CHORD, CENTERLINE ROOT		818.02 IN
CHORD, TIP		119.99 IN
TAPER RATIO, THEORETICAL		.14668
ASPECT RATIO, THEORETICAL		2.3143
ASPECT RATIO, EXPOSED SPAN		2.1747
ANGLE, LEADING EDGE SWEEP		50.172 DEG
ANGLE, TRAILING EDGE SWEEP		-7.0 DEG
ANGLE, DIHEDRAL	*FIXED*	7.0 DEG
ANGLE, INCIDENCE	*FIXED*	1.5 DEG
AIRFOIL SECTION, ROOT	*FIXED*	008-64
AIRFOIL SECTION, TIP	*FIXED*	008-64

4. 040A MASS PROPERTIES			
FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC L)
ORBITER LNDG (W/40K PL)	201478.4	71.606	65.346
ORBITER LNDG (W/O PL)	161478.4	74.027	67.555
WING WEIGHT	16828.1		
TPS WEIGHT	28544.3		

5. PRINCIPAL PARAMETERS	
X-SCALE FACTOR	SCLX= .90000
Y-SCALE FACTOR	SCLY= 1.3000
DISTANCE TO LEADING EDGE OF EXPOSED WING	XOF=628.134 IN
6. LANDING PERFORMANCE	
MINIMUM LANDING SPEED (W/40K PL)	150.0 KT
STATIC MARGIN (SUBSONIC) (W/40K PL)	-.0804
STATIC MARGIN (SUBSONIC) (W/O PL)	-.0281
TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)	.7480
7. HYPERSONIC AERODYNAMIC TRIM DATA	
TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG	40.81 DEG

ODIN Wing W_{33} (Modified)

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1. OVERALL CONFIGURATION
      AREA, PLANFORM (SFT)                                   4069.3
      LENGTH, NOSE TO WING LE AT BODY                        651.70 IN
      LENGTH, NOSE TO WING C/4                               892.80 IN
      ANGLE, GROUND PLANE                         *FIXED*    17.00 DEG

2. FUSELAGE
      AREA, WETTED                                *FIXED*    6307.0 SFT
      LENGTH, NOSE TO END OF BODY                 *FIXED*    1315.0 IN

3. WING
      AREA, THEORETICAL OR TOTAL                             3387.1 SFT
      AREA, ELEVON                                           731.03 SFT
      SPAN                                                   1085.4 IN
      CHORD, MEAN AERCDYNAMIC                                536.52 IN
      CHORD, CENTERLINE ROOT                                 792.09 IN
      CHORD, TIP                                             106.66 IN
      TAPER RATIO, THEORETICAL                               .13465
      ASPECT RATIO, THEORETICAL                              2.4154
      ASPECT RATIO, EXPOSED SPAN                             2.2896
      ANGLE, LEADING EDGE SWEEP                              46.825 DEG
      ANGLE, TRAILING EDGE SWEEP                             -11.0 DEG
      ANGLE, DIHEDRAL                             *FIXED*      7.0 DEG
      ANGLE, INCIDENCE                            *FIXED*      1.5 DEG
      AIRFOIL SECTION, ROOT                       *FIXED*    008-64
      AIRFOIL SECTION, TIP                        *FIXED*    008-64

4. 040A MASS PROPERTIES
      FLIGHT CONDITION              WEIGHT (LB)    X-CG (FT)    X-CG (PC L)
      ORBITER LNDG (W/40K PL)       199609.0       71.181       64.958
      ORBITER LNDG (W/O PL)         159609.0       73.523       67.096
      WING WEIGHT                   16476.8
      TPS WEIGHT                    27026.2

5. PRINCIPAL PARAMETERS
      X-SCALE FACTOR                                     SCLX= .80000
      Y-SCALE FACTOR                                     SCLY= 1.3000
      DISTANCE TO LEADING EDGE OF EXPOSED WING            XOF=651.696 IN

6. LANDING PERFORMANCE
      MINIMUM LANDING SPEED (W/40K PL)                       149.9 KT
      STATIC MARGIN (SUBSONIC)    (W/40K PL)                 -.0804
      STATIC MARGIN (SUBSONIC)    (W/O PL)                   -.0280
      TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)              .7742

7. HYPERSONIC AERODYNAMIC TRIM DATA
      TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG                 48.90   DEG
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NASA-Langley, 1974 L-9099

ODIN Wing W_{33}

1. OVERALL CONFIGURATION

AREA, PLANFORM (SFT)		3803.4
LENGTH, NOSE TO WING LE AT BODY		663.70 IN
LENGTH, NOSE TO WING C/4		890.35 IN
ANGLE, GROUND PLANE	*FIXED*	17.00 DEG

2. FUSELAGE

AREA, WETTED	*FIXED*	6307.0 SFT
LENGTH, NOSE TO END OF BODY	*FIXED*	1315.0 IN

3. WING

AREA, THEORETICAL OR TOTAL		2984.0 SFT
AREA, ELEVON		473.74 SFT
SPAN		1085.4 IN
CHORD, MEAN AERODYNAMIC		466.34 IN
CHORD, CENTERLINE ROOT		685.10 IN
CHORD, TIP		106.66 IN
TAPER RATIO, THEORETICAL		.15568
ASPECT RATIO, THEORETICAL		2.7417
ASPECT RATIO, EXPOSED SPAN		2.5808
ANGLE, LEADING EDGE SWEEP		46.825 DEG
ANGLE, TRAILING EDGE SWEEP	*FIXED*	0.0 DEG
ANGLE, DIHEDRAL	*FIXED*	7.0 DEG
ANGLE, INCIDENCE	*FIXED*	1.5 DEG
AIRFOIL SECTION, ROOT	*FIXED*	008-64
AIRFOIL SECTION, TIP	*FIXED*	008-64

4. 040A MASS PROPERTIES

FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC L)
ORBITER LNDG (W/40K PL)	199970.6	71.202	64.977
ORBITER LNDG (W/O PL)	159970.6	73.545	67.115
WING WEIGHT	16838.4		
TPS WEIGHT	27026.2		

5. PRINCIPAL PARAMETERS

X-SCALE FACTOR	SCLX= .80000
Y-SCALE FACTOR	SCLY= 1.3000
DISTANCE TO LEADING EDGE OF EXPOSED WING	XOF=663.696 IN

6. LANDING PERFORMANCE

MINIMUM LANDING SPEED (W/40K PL)	153.8 KT
STATIC MARGIN (SUBSONIC) (W/40K PL)	-.0900
STATIC MARGIN (SUBSONIC) (W/O PL)	-.0297
TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)	.8366

7. HYPERSONIC AERODYNAMIC TRIM DATA

TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG	45.66 DEG

ODIN Wing W_{34}

1. OVERALL CONFIGURATION

AREA, PLANFORM (SFT)		3260.7
LENGTH, NOSE TO WING LE AT BODY		706.16 IN
LENGTH, NOSE TO WING C/4		895.99 IN
ANGLE, GROUND PLANE	*FIXED*	17.00 DEG

2. FUSELAGE

AREA, WETTED	*FIXED*	6307.0 SFT
LENGTH, NOSE TO END OF BODY	*FIXED*	1315.0 IN

3. WING

AREA, THEORETICAL OR TOTAL		2341.8 SFT
AREA, ELEVON		350.75 SFT
SPAN		949.80 IN
CHORD, MEAN AERODYNAMIC		419.37 IN
CHORD, CENTERLINE ROOT		616.76 IN
CHORD, TIP		93.324 IN
TAPER RATIO, THEORETICAL		.15131
ASPECT RATIO, THEORETICAL		2.6752
ASPECT RATIO, EXPOSED SPAN		2.4957
ANGLE, LEADING EDGE SWEEP		47.782 DEG
ANGLE, TRAILING EDGE SWEEP	*FIXED*	0.0 DEG
ANGLE, DIHEDRAL	*FIXED*	7.0 DEG
ANGLE, INCIDENCE	*FIXED*	1.5 DEG
AIRFOIL SECTION, ROOT	*FIXED*	008-64
AIRFOIL SECTION, TIP	*FIXED*	008-64

4. 040A MASS PROPERTIES

FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC L)
ORBITER LNDG (W/40K PL)	195128.5	70.687	64.507
ORBITER LNDG (W/O PL)	155128.5	72.970	66.591
WING WEIGHT	14939.6		
TPS WEIGHT	24082.8		

5. PRINCIPAL PARAMETERS

X-SCALE FACTOR	SCLX= .70000
Y-SCALE FACTOR	SCLY= 1.1000
DISTANCE TO LEADING EDGE OF EXPOSED WING	XOF=706.163 IN

6. LANDING PERFORMANCE

MINIMUM LANDING SPEED (W/40K PL)	171.4 KT
STATIC MARGIN (SUBSONIC) (W/40K PL)	-.0940
STATIC MARGIN (SUBSONIC) (W/O PL)	-.0286
TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)	.8380

7. HYPERSONIC AERODYNAMIC TRIM DATA

TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG	59.10 DEG

ODIN Wing W_{35}

1. OVERALL CONFIGURATION

AREA, PLANFORM (SFT)		3401.4
LENGTH, NOSE TO WING LE AT BODY		699.20 IN
LENGTH, NOSE TO WING C/4		893.63 IN
ANGLE, GROUND PLANE	*FIXED*	17.00 DEG

2. FUSELAGE

AREA, WETTED	*FIXED*	6307.0 SFT
LENGTH, NOSE TO END OF BODY	*FIXED*	1315.0 IN

3. WING

AREA, THEORETICAL OR TOTAL		2475.9 SFT
AREA, ELEVON		382.64 SFT
SPAN		1017.6 IN
CHORD, MEAN AERODYNAMIC		413.23 IN
CHORD, CENTERLINE ROOT		607.39 IN
CHORD, TIP		93.324 IN
TAPER RATIO, THEORETICAL		.15365
ASPECT RATIO, THEORETICAL		2.9044
ASPECT RATIO, EXPOSED SPAN		2.7226
ANGLE, LEADING EDGE SWEEP		45.294 DEG
ANGLE, TRAILING EDGE SWEEP	*FIXED*	0.0 DEG
ANGLE, DIHEDRAL	*FIXED*	7.0 DEG
ANGLE, INCIDENCE	*FIXED*	1.5 DEG
AIRFOIL SECTION, ROOT	*FIXED*	008-64
AIRFOIL SECTION, TIP	*FIXED*	008-64

4. 040A MASS PROPERTIES

FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC L)
ORBITER LNDG (W/40K PL)	196714.8	70.746	64.561
ORBITER LNDG (W/O PL)	156714.8	73.021	66.637
WING WEIGHT	15812.6		
TPS WEIGHT	24796.1		

5. PRINCIPAL PARAMETERS

X-SCALE FACTOR	SCLX= .70000
Y-SCALE FACTOR	SCLY= 1.2000
DISTANCE TO LEADING EDGE OF EXPOSED WING	XOF=699.198 IN

6. LANDING PERFORMANCE

MINIMUM LANDING SPEED (W/40K PL)	163.4 KT
STATIC MARGIN (SUBSONIC) (W/40K PL)	-.0949
STATIC MARGIN (SUBSONIC) (W/O PL)	-.0289
TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)	.8787

7. HYPERSONIC AERODYNAMIC TRIM DATA

TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG	56.69 DEG

ODIN Wing W_{27} (Modified)

1. OVERALL CONFIGURATION

AREA, PLANFORM (SFT)		4182.2
LENGTH, NOSE TO WING LE AT BODY		628.13 IN
LENGTH, NOSE TO WING C/4		889.39 IN
ANGLE, GROUND PLANE	*FIXED*	17.00 DEG

2. FUSELAGE

AREA, WETTED	*FIXED*	6307.0 SFT
LENGTH, NOSE TO END OF BODY	*FIXED*	1315.0 IN

3. WING

AREA, THEORETICAL OR TOTAL		3535.1 SFT
AREA, ELEVON		646.66 SFT
SPAN		1085.4 IN
CHORD, MEAN AERODYNAMIC		555.61 IN
CHORD, CENTERLINE ROOT		818.02 IN
CHORD, TIP		119.99 IN
TAPER RATIO, THEORETICAL		.14668
ASPECT RATIO, THEORETICAL		2.3143
ASPECT RATIO, EXPOSED SPAN		2.1747
ANGLE, LEADING EDGE SWEEP		50.172 DEG
ANGLE, TRAILING EDGE SWEEP		-7.0 DEG
ANGLE, DIHEDRAL	*FIXED*	7.0 DEG
ANGLE, INCIDENCE	*FIXED*	1.5 DEG
AIRFOIL SECTION, ROOT	*FIXED*	008-64
AIRFOIL SECTION, TIP	*FIXED*	008-64

4. 040A MASS PROPERTIES

FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC L)
ORBITER LNDG (W/40K PL)	201478.4	71.606	65.346
ORBITER LNDG (W/O PL)	161478.4	74.027	67.555
WING WEIGHT	16828.1		
TPS WEIGHT	28544.3		

5. PRINCIPAL PARAMETERS

X-SCALE FACTOR	SCLX= .90000
Y-SCALE FACTOR	SCLY= 1.3000
DISTANCE TO LEADING EDGE OF EXPOSED WING	XOF=628.134 IN

6. LANDING PERFORMANCE

MINIMUM LANDING SPEED (W/40K PL)	150.0 KT
STATIC MARGIN (SUBSONIC) (W/40K PL)	-.0804
STATIC MARGIN (SUBSONIC) (W/O PL)	-.0281
TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)	.7480

7. HYPERSONIC AERODYNAMIC TRIM DATA

TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG	40.81 DEG

ODIN Wing W_{33} (Modified)

1. OVERALL CONFIGURATION

AREA, PLANFORM (SFT)		4069.3
LENGTH, NOSE TO WING LE AT BODY		651.70 IN
LENGTH, NOSE TO WING C/4		892.80 IN
ANGLE, GROUND PLANE	*FIXED*	17.00 DEG

2. FUSELAGE

AREA, WETTED	*FIXED*	6307.0 SFT
LENGTH, NOSE TO END OF BODY	*FIXED*	1315.0 IN

3. WING

AREA, THEORETICAL OR TOTAL		3387.1 SFT
AREA, ELEVON		731.03 SFT
SPAN		1085.4 IN
CHORD, MEAN AERODYNAMIC		536.52 IN
CHORD, CENTERLINE ROOT		792.09 IN
CHORD, TIP		106.66 IN
TAPER RATIO, THEORETICAL		.13465
ASPECT RATIO, THEORETICAL		2.4154
ASPECT RATIO, EXPOSED SPAN		2.2896
ANGLE, LEADING EDGE SWEEP		46.825 DEG
ANGLE, TRAILING EDGE SWEEP		-11.0 DEG
ANGLE, DIHEDRAL	*FIXED*	7.0 DEG
ANGLE, INCIDENCE	*FIXED*	1.5 DEG
AIRFOIL SECTION, ROOT	*FIXED*	008-64
AIRFOIL SECTION, TIP	*FIXED*	008-64

4. 040A MASS PROPERTIES

FLIGHT CONDITION	WEIGHT (LB)	X-CG (FT)	X-CG (PC L)
ORBITER LNDG (W/40K PL)	199609.0	71.181	64.958
ORBITER LNDG (W/O PL)	159609.0	73.523	67.096
WING WEIGHT	16476.8		
TPS WEIGHT	27026.2		

5. PRINCIPAL PARAMETERS

X-SCALE FACTOR	SCLX= .80000
Y-SCALE FACTOR	SCLY= 1.3000
DISTANCE TO LEADING EDGE OF EXPOSED WING	XOF=651.696 IN

6. LANDING PERFORMANCE

MINIMUM LANDING SPEED (W/40K PL)	149.9 KT
STATIC MARGIN (SUBSONIC) (W/40K PL)	-.0804
STATIC MARGIN (SUBSONIC) (W/O PL)	-.0280
TRIM LIFT COEF FOR LANDING (ALPHA=17 DEG)	.7742

7. HYPERSONIC AERODYNAMIC TRIM DATA

TRIM ANGLE OF ATTACK AT ELEVON=-45 DEG	48.90 DEG

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